U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—BULLETIN No. 26.

MILTON WHITNEY, Chief.

INVESTIGATIONS IN SOIL MANAGEMENT.

Part I. AMOUNT OF PLANT FOOD READILY RECOVERABLE FROM FIELD SOILS WITH DISTILLED WATER.

Part II. RELATION OF CROP YIELDS TO THE AMOUNTS OF WATER-SOLUBLE PLANT-FOOD MATERIALS RECOVERED FROM SOILS.

Part III. RELATION OF DIFFERENCES OF CLIMATOLOGICAL ENVIRONMENT TO CROP YIELDS.

BY

PROF. F. H. KING,

CHIEF OF THE DIVISION OF SOIL MANAGEMENT.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1905.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Soils,
Washington, D. C., July 1, 1904.

Sir: I have the honor to transmit herewith six manuscripts prepared by Prof. F. H. King. The three articles respectively entitled, "Amount of plant food readily recoverable from field soils with distilled water," "Relation of crop yields to the amounts of water-soluble plant-food materials recovered from soils," and "Relation of differences of climatological environment to crop yields," are records of the field work recently carried on under Professor King's direction, together with some discussion and conclusions derived therefrom, and might be published under the general title, "Investigations in soil management." The facts presented are interesting and suggestive, and will be helpful to students of the soil; and seem, therefore, to call for publication, notwithstanding the fact that the opinions and conclusions which have been drawn from these facts must be considered as the personal views of the author, and in the main do not carry the indorsement of this Bureau. Moreover, the manner of presenting the facts has been naturally influenced by the conclusions the author has drawn from the experimental data; hence, while the experimental data may safely be accepted as statements of fact, the manner of presentation of the facts and the conclusions drawn therefrom must be accepted as merely the expression of the opinions held by the author. With this explanation I recommend that these papers be published as a bulletin of this Department.

The other three articles which were submitted by the author are entitled, "Absorption of water soluble salts by different soil types," "Influence of farmyard manure upon yields and upon water-soluble salts of soils," and "The movement of water-soluble salts in soils." These articles deal in part with the experimental data presented in the first two papers and in part with laboratory experiments which the author himself states are of a preliminary character. In my judgment the investigations described in these papers are not sufficiently mature to justify departmental publication of the results so far obtained, and in their present form. I therefore recommend that

these manuscripts be not published by the Department, but that permission be granted Professor King to publish in journals, if he so desires. Professor King severed his connection with the Department on June 30, 1904.

MILTON WHITNEY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

PREFACE.

In April, 1902, under the direction of the Chief of the Bureau of Soils and by authority of the Secretary of Agriculture, an investigation was undertaken at Goldsboro, N. C., regarding the amounts of readily water-soluble salts which may be recovered from different soil types under field conditions. The work was prosecuted during the season upon six soil types in that locality, which had been mapped by the Bureau. Toward the close of the season, in August and September, in compliance with the instructions of the Chief of the Bureau, a reconnoissance was made to determine the readily water-soluble salts of the important soil types in a number of areas surveyed by the Bureau in Georgia, South Carolina, North Carolina, Virginia, Maryland, New Jersey, Pennsylvania, and Wisconsin.

In March, 1903, after field methods had been devised for the determination of potash, lime, and magnesia, a more critical and systematic study was undertaken of the water-soluble salts in eight important soil types, two in each of the four States—North Carolina, Maryland, Pennsylvania, and Wisconsin. These investigations were closed in the field in October, 1903, and in the laboratory February 1, 1904. The results are presented in Part I of this bulletin.

One of the most important objects of these investigations was to ascertain what relation, if any, exists between the character and amounts of the water-soluble salts present in a soil and the yield and quality of crop matured upon it at the same time. In planning and executing those studies the work was so shaped that as far as possible the investigations should be made in direct connection with some crop or crops whose yields could be definitely ascertained and whose growth was under observation.

In Part II of this bulletin are presented such quantitative and qualitative relations as have been observed between the yields and the conditions of growth of crops during the years 1902 and 1903. The whole work has been, in its fullest sense, a study of existing field conditions and relations, and the work of 1903 especially was a critical comparative study of eight soil types, bearing the same two crops, where all of the conditions under control were made as closely similar as practicable.

In connection with these soil studies a series of climatological investigations have been conducted. The results, which are embodied in Part III of this bulletin, are those secured during the year 1903. They include records of the rainfall during the growing season, which was associated with the crops grown in the four States and on eight soil types. With the rainfall records there is another series giving the percentages of sunshine during the growing season at the four stations.

A comparative soil temperature study was also made which, so far as I am aware, is unique in that simultaneous records have been obtained at four widely separated stations and from eight soil types. These records cover four depths and also include autographic records of the temperature of the eight soils at one foot below the surface. There was also obtained a simultaneous autographic record of the temperature in a closed shelter 4 feet above the surface in a corn field at each of the four stations.

A soil moisture study was made which is also unique in that it furnishes a weekly record throughout the growing season of the variations of soil moisture in the surface foot of eight soil types under three crop conditions. With these weekly records there are presented biweekly records of the moisture conditions in the second foot, and records of the water content of the third and fourth feet at the beginning, in the middle, and at the close of the growing season.

Another line of work here reported gives the results of a study of the relative rates of evaporation from firm soil surfaces, continuously saturated by capillarity, at the four stations throughout the growing season, and also the evaporation of water from ten stalks of corn and the soil surface upon which they grew at each of the stations.

The last section of Part III contains the results of a comparative soil moisture study made on eight soil types, in which the effect of limiting the capillary supply of moisture and of excluding the rainfall, upon the growth of corn and upon the water content of the soil, has been determined. In other words corn has been grown to maturity on eight soil types without rain, the only available moisture being that contained in the soil at the time of planting or obtained through capillarity from below.

During the investigations of 1902, Mr. J. O. Belz made the determinations for nitric, sulphuric, and phosphoric acids, and silica; Mr. A. T. Strahorn made those for chlorin and the bicarbonates; and Mr. W. C. Palmer determined the total salts in the soil extracts by the electrical method, and made the soil moisture determinations. Dr. Herman Schlundt, assisted by Dr. Oswald Schreiner and Dr. R. D. Hall, made similar determinations on some soils in Wisconsin between July 10 and September 15.

In the investigations of 1903, Mr. Palmer had charge of the field work at Goldsboro, N. C., assisted by F. R. Pember and F. C. Schroeder; Mr. J. W. Nelson had charge at Upper Marlboro, Md., assisted by J. C. Hogenson and H. L. Belden; Mr. Belz, at Lancaster, Pa., assisted by Jay F. Warner and A. T. Strahorn; and Mr. A. H. Snyder, at Janesville, Wis., assisted by F. D. Stevens and W. S. Lyman. Dr. Oswald Schreiner, assisted by W. S. Ferris, has had charge of developing, adapting, and checking the field methods. The early determinations for potash were made by Mr. Ferris and the balance by Mr. Belz, who, with Mr. Snyder, made the determinations for magnesia. The determinations for lime and sulphuric acid were begun by Mr. Snyder and finished by Mr. Palmer and Mr. Hogenson. Mr. Nelson made the determinations for phosphoric acid and silica, and Mr. William Detrich and Mr. Stevens those for chlorine and the bicarbonates. Mr. Pember made those for nitric acid. To Doctor Schriener is due the credit of developing the methods used for the determination of magnesia, phosphoric acid, silica, and lime. He also put into working shape our plan for a standard glass colorimeter which substitutes unchangeable colored glasses for standard solutions, which must be prepared from day to day. The conduct of the investigations and the collection of the data presented in Parts II and III were also in the hands of the coworkers named above. It has been necessary to conduct the whole of this investigation so entirely as a single piece of work in which each man has performed a definite part that the credit due to the individual can not be made so apparent as is possible with purely individual work.

The three parts of this bulletin were originally prepared, in accordance with the advice of the Secretary of Agriculture, to be printed as separate bulletins; they appear here, including the preface, as arranged by the editors, but with no essential alteration of the subject matter.

F. H. KING.

CONTENTS.

PART I.—AMOUNT OF PLANT FOOD READILY RECOVERABLE FROM FIELD SOILS WITH DISTILLED WATER.

PART III.—RELATION OF DIFFERENCES OF CLIMATOLOGICAL ENVIRONMENT TO CROP YIELDS.

ILLUSTRATIONS.

PLATES.

TEXT FIGURES.

INVESTIGATIONS IN SOIL MANAGEMENT.

PART I.—AMOUNT OF PLANT FOOD READILY RECOVERABLE FROM FIELD SOILS WITH DISTILLED WATER.

OBJECTS OF THE INVESTIGATION.

In undertaking a systematic investigation of the problems of soil management, which should lead to the placing of empirical practices upon a more rational basis and to a better understanding of the principles of soil fertility, it appeared imperative that means and methods should be adopted which would be capable of detecting and measuring those effects upon the soil which result from different methods of soil management and which are known to be reflected in the yields of the crop growing upon the field under treatment.

While, during the last three quarters of a century of effort in both field and laboratory studies, very much of the highest value has been accomplished, it has still to be admitted that no physical, chemical, nor biological examination of a soil has yet been so made or understood that the observed data may be used in computing, for favorable climatic conditions, its productive capacity for or its adaptability to any crop. This is neither as it should be nor as the future will have it. Not only are there no reasons for doubting, but there are many for believing, that the biological, chemical, and physical differences in soils do determine both their productive capacities and their adaptation to certain crops. Not only this, but there is every assurance that, when methods shall have been devised which will permit such differences in soils as do determine differences in yield to be detected and measured, it will then be practicable both to foresee possibilities and with certainty and economy to direct industrial effort.

It was a long and laborious research, which finally, of necessity, became one of great refinement, before suitable methods and appliances were devised for properly rating a newly discovered iron ore and for pointing out the quality of iron and steel which could be obtained from it, and it was only after due attention was given to the great "influence of the next-to-nothing" associated with the iron ore, in determining the quality of the product, that the solutions of the important underlying practical problems were reached. When it came to be recog-

nized that the presence of very minute quantities of certain ingredients exerted an enormous influence upon the quality of the iron, progress became rapid, easy, and certain.

In 1894, when writing upon the subject of soil fertility, after pointing out the apparently very large amounts of plant food carried by most soils, the writer was led to remark:[a]

Notwithstanding the apparently inexhaustible stores of potash, magnesia, lime, phosphoric acid, etc., in the soil (as indicated by chemical analysis), it must be remembered that we are nevertheless confronted with the indisputable results of practical field work, which show, very often at least, that the addition of purely mineral fertilizers have been associated with larger yields per acre. We are confronted on every hand, too, with the fact that lands do run out, and some varieties much sooner than others, so that, when all has been said, the most important fact to bear in mind is that here is a problem lying at the very foundations of agriculture upon which a vast work has yet to be done.

In support of this view let me place in evidence some of the results of Sir J. B. Lawes and his associates during their classic experiments bearing upon the conditions which determine the fertility of soils. By growing various crops year after year on the same land, to which no nitrogen-bearing manures were applied, they found that when purely mineral fertilizers were added the crops were able to produce larger yields and to extract more nitrogen from the soil than when these fertilizers were omitted. Wheat, for example, grown continuously on the same land for thirty-two years, without manures of any kind, was able to extract from the soil and build into its product 20.7 pounds of nitrogen per acre per annum, but the same crop on adjacent and similar lands to which mineral fertilizers without nitrogen were added was able to gather and store 22.1 pounds, an amount 6.76 per cent larger. Barley, during twenty-four consecutive years, drew from the soil 18.3 pounds of nitrogen per annum where no mineral fertilizers were added, but 22.4 pounds per acre under the stimulus of them. Beans gathered from their land 31.3 pounds of nitrogen per acre where no fertilizer was added, as an average of twenty-four years, but 45.5 pounds where complex mineral food was given them. Ground bearing 6 crops of clover in twenty-two years, with 1 of wheat, 3 of barley, and 12 of fallow ground, gave, without fertilizers, 30.5 pounds of nitrogen per acre, but with the mineral fertilizers, 39.8 pounds. So, too, in a rotation of crops, 7 courses in twenty-eight years, no fertilizers gave 36.8 pounds, while with superphosphate of lime the yield was 45.2 pounds per acre. Then, again, in the mixed herbage of grass land, twenty years without fertilizers gave a mean yield of 38 pounds, but, with a mixed mineral fertilizer containing potash, the product of nitrogen was 55.6 pounds per acre per annum.

Such facts as these place beyond question the fact that, in spite of the large stores in the soil of all the ash ingredients used by plants, the addition of mineral salts, more or less closely allied to those found there, do give to the plant an added power over the natural resources of the soil in which they may be growing; and the marvelous part of the whole problem is that so small an amount of the fertilizer, when diluted by so much soil and water, can exert the appreciable effects observed.

Again, in speaking at the same time in regard to the large amounts of nitrogen stored in most soils, it was said:

The presence of these large amounts of nitrogen and of ash ingredients, which soils have been shown to possess, are very fundamental facts, which must ever be kept in mind in our efforts to restore the vigor of exhausted soils, and to maintain a high degree of productiveness in them when so brought back. They are important

[a] The Soil, King, p. 104.

because they show very clearly that run-out lands, and lands "tired" of this crop or of that, have been rendered so by some change different from the consumption of the chemical ingredients (as indicated by soil analyses) contained in the soil out of which plant food is elaborated. They are important because they bring clearly into view the fact that, as yet, our practices regarding the rotation of crops, regarding the fertilizers or manures for this soil or that crop, and regarding many of our efforts to improve our lands by this or that method of tillage, are all of them far too much like those of a man feeling his way in the dark.

Each year, since expressing these views, the conviction has been growing stronger that, before we can hope to solve the problems of soil fertility and thereby lay the foundations of soil management, investigations must be directed along other lines. The long recognized extremely important part played by soil moisture in crop production, together with the failure of investigations regarding variations in the available amounts of it to explain the observed differences in yields, has made it appear to the writer very important to investigate, more fully than has yet been done, the character of the soil moisture itself, and especially since it has long been recognized as the immediate source of the materials out of which plant food is elaborated. Since the soil moisture is a nutritive solution carried mechanically by, and reenforced from, the soil, and since variations in the composition, strength, and character of "water-culture" solutions, which have contributed so much to our knowledge of the specific functions of the essential ash ingredients of plants, have been found to materially influence growth, it is clearly of fundamental importance to establish: (1) Whether, in soils of different types, the amounts and character of the readily water-soluble salts are measurably different; (2) if these differences are in any way related to the needs of the crops to which the soils appear to be specially well adapted; (3) if differences in yield are related in any measurable way to the amounts or character of the readily water-soluble salts of the soil; (4) if recognized good and poor soil management does influence the water-soluble salts in such a way as to help explain the observed differences in yield; (5) if crops themselves exert a differential effect upon the amounts of the essential ash ingredients carried in readily water-soluble form in the soil; and (6) if the plant sap of crops, growing upon different soils, shows variations in strength and character which are related to the water-soluble salts in the soil and to the yields of crops upon them.

In view of the work which was done between 1845 and 1865, somewhat along these lines, but more especially regarding the absorptive power of soils for different fertilizer ingredients; and in view of Johnson's masterful digest of the evidence which had accumulated up to the close of this period, and the insight—in many ways remarkable—with which he illuminated the data he brought together, it appears strange that so little, relatively, should have been done along either of these two lines since that time, and more especially since the subjects were

recognized as important and as being incompletely developed. It was after the writer's studies regarding the relations of soil moisture to crop yields that he was led to the investigations of the nature and variations of soil solutions under field conditions, which were begun at the Wisconsin Agricultural Experiment Station in 1899[a] and continued until the close of 1901, studying chiefly the variations in the nitric acid content of soils throughout the season and under different crop and soil conditions. An effort was also made to simultaneously study the relation of the total dissolved salts in soils to the yields of crops by taking advantage of the electrical method devised by this Bureau for the investigation of alkali problems, but after one season's trial it appeared not to be adapted to such dilute solutions as are found in soils in good cultural condition, and its use was discontinued.

RESULTS OF EARLIER INVESTIGATIONS.

The writer has found no reference in the literature of this subject to any systematic effort to investigate either the amounts of readily water-soluble salts carried by soils, or the relation of these amounts to crop yields from them. A considerable amount of work has been done, however, bearing upon the general problem whether the soil moisture does carry sufficient amounts of the different ash ingredients to meet the need of crops; and some of the results of these earlier investigations are here cited.

Grouven,[b] in 1858, washed by percolation three different soils, using water in the ratio of 3 of water to 1 of soil; the results of his analyses of the respective filtrates are given below:

Salts recovered by percolation of cold water through three soils (Grouven, 1858).

[Parts per million of dry soil.]

Constituent.	Poor sandy soil—Bickendorf.	Garden soil—Heidelberg.	Garden soil—Cologne.
	(1)[c]	(2)[c]	(3)[c]
Potash	5.00	69.00	89.00
Lime	84.00	234.00	173.00
Magnesia	6.20	16.00	30.00
Soda	35.70	46.00	76.00
Alumina	7.80	....	4.00
Iron oxide	10.40	....	8.00
Phosphoric acid	Trace.	14.00	52.00
Sulphuric acid	15.20	9.00	57.00
Carbonic acid	92.00	110.00	90.00
Chlorine	.70	15.00	27.00
Silica	199.20	384.00	135.00
Organic matter (nitric acid and ammonia)	101.00	306.00	217.00
Sum	557.20	1,203.00	958.00

[a] Annual Reports Wisconsin Agricultural Experiment Station for 1899, 1900, and 1901, Bulletins 85 and 93; also Bulletin 69, Office of Experiment Stations, United States Department of Agriculture.
[b] Hoffman's Jahresbericht über die Agriculturchemie, 1858–59, p. 14.
[c] Certain columns in this and succeeding tables are numbered for convenience of reference when brought together in the general table, page 21.

E. Peters[a] in 1860 treated 100 grams of an air-dry soil (containing 6.85 per cent moisture when dried at 110° C.) 24 hours with 250 cc of water, and then analyzed the solution which could be drawn off from above the soil. The results obtained have been computed to the water-free soil and given in the first column of the table in parts per million. Two other samples of the same soil were analyzed, one after extraction in 1 to 3 hydrochloric acid and the other by the usual method of that time. These results appear also in the table. The soil was one derived from the disintegration of a claystone porphyry.

Salts recovered from soils with water and dilute hydrochloric acid (Peters, 1860).

Salts.	Digested in— Water only.	Digested in— Hydrochloric acid.	Complete analysis.
	Parts per million of dry soil. (4)	*Per cent of dry soil.*	*Per cent of dry soil.*
Potash	25.77	0.0636	0.245
Lime	124.50	.3528	.500
Magnesia	25.77	.0070	.215
Soda	18.25	.0510	.255
Alumina and iron oxide	33.28	(?)	13.750
Phosphoric acid	(?)	.1024	.110
Sulphuric acid	20.40	.0240	(?)
Chlorine	40.80	(?)	(?)
Silica	66.57	(?)	81.70
Total	355.34	....	....

Two other soils and their subsoils were examined by E. Peters[b] treating one set with five times their dry weights of water and another set with dilute nitric acid. The results appear in the following table:

Salts recovered from soils with water and with dilute nitric acid (Peters, 1860.)

[In parts per million of dry soil.]

	Surface soil.				Subsoil.			
	Leitendorf.		Lampertsdorf.		Leitendorf.		Lampertsdorf.	
	In water.	In nitric acid.	In water.	In nitric acid.	In water.	In nitric acid.	In water.	In nitric acid.
	(5)		(6)		(7)		(8)	
Potash	40	380	10	670	(?)	420	(?)	480
Lime	60	2,410	100	2,020	70	2,130	110	570
Magnesia	10	670	Trace.	70	10	570	0	110
Soda	40	50	20	30	(?)	10	(?)	60
Iron oxide	....	9,960	....	18,810	....	19,140	....	11,080
Alumina	....	4,500	....	5,400	....	9,200	....	4,700
Phosphoric acid	....	640	....	890	....	960	....	320
Sulphuric acid	10	70	10	130	Trace.	30	Trace.	70
Chlorine	Trace.	....	Trace.	....	....	....	....	....
Silica	20	600	110	740	40	720	80	1,270
Total mineral matter	240	....	330	....	160	....	240	....
Organic matter	230	....	180	....	70	....	170	....

[a] Die Landwirthschaftlichen Versuchs-Stationen, Volume II, 1860, p. 113.
[b] Hoffman's Jahresbericht über die Agriculturchemie, 1861–1862, pp. 34–35.

V. Jarriges,[a] in 1860, also determined the water-soluble salts recoverable from three soils by treating them with five times their dry weight of cold water. He also digested another sample in hydrochloric acid and the results of these analyses are given in the next table:

Salts recovered from soils with water and with hydrochloric acid (Jarriges, 1860).

[In parts per million of dry soil.]

	Soil (a) soluble in—		Soil (b) soluble in—		Soil (c) soluble in—	
	Cold water.	Hydrochloric acid.	Cold water.	Hydrochloric acid.	Cold water.	Hydrochloric acid.
	(9)		(10)		(11)	
Potash	30	2,030	85	1,850	100	1,490
Lime	50	3,460	160	7,550	700	28,080
Magnesia	25	2,260	35	2,340	55	4,170
Soda	55	460	40	1,230	55	1,030
Oxide of iron and alumina	66	50,700	85	48,600	25	41,290
Phosphoric acid	Little.	1,070	Trace.	850	More.	1,310
Sulphuric acid	Trace.	610	Little.	440	More.	1,980
Chlorine	Little.	....	Little.	....	More.	....
Silica	45	1 130	85	1,000	300	1,030
Sum	271	61,720	490	63,860	1,235	80,380
Organic matter	240	....	790	....	710	....

R. Hoffman[b] determined the water-soluble salts in four soils—a peat, a peaty soil, a clay soil, and a light sandy soil—obtaining his solutions by percolation, using cold distilled water, and aiming to employ so much that the filtrate would come away so free from soluble matter that no traces of chlorin or sulphuric acid remained. To 500 grams of the Meronitz peat he added 8,000 cc of distilled water; to the Techobus peaty soil, 8 times its weight of water; to the Liebesnitz clay soil, 4,800 cc to 500 grams of soil; and to the Moldau Valley sandy soil, 1,000 cc of water to 500 grams of soil.

The clayey soil used in this study was taken from a sugar-beet field, apparently just at the close of the season before the crop was harvested. The sandy soil contained 12 per cent of gravel, 43 per cent of coarse sand, 25 per cent of fine sand, and 20 per cent of finest clay material. In the following table appear the results obtained:

Salts recovered from soils with water (Hoffman).

[In parts per million of dry soil.]

	Meronitz peat.	Techobus peaty soil.	Liebesnitz clay soil.	Moldau Valley sandy soil.
	(12)	(13)	(14)	(15)
Potash	470.0	210.0	46.2	21.0
Lime	1,640.0	920.0	336.0	10.0
Magnesia	110.0	440.0	33.7	24.0
Soda	120.0	240.0	89.0	9.0
Oxide of iron and alumina	770.0	20.0	....	....
Phosphoric acid	Trace.	Trace.	53.7	Trace.
Sulphuric acid	3,020.0	110.0	178.0	Trace.
Chlorine	330.0	Trace.	34.6	Trace.
Silica	Trace.	10.0	Trace.	Trace.
Sum	6,460.0	1,950.0	771.2	64.0
Organic matter	4,490.0	2,300.0	700.0	332.0

[a] Hoffman's Jahresbericht über die Agriculturchemie, 1861–1862, p. 36.

[b] Die Landwirthschaftlichen Versuchs-Stationen, Volume V, pp. 193–194.

Doctor Wunder[a] and Doctor Eichhorn each examined soils, in a different manner from the preceding, endeavoring to obtain a solution more nearly of a strength comparable with that which might be drained away from a soil simply fully saturated with water. To this end Wunder introduced into a flask 5 kilos of air-dry soil and to this added 1.73 kilos of distilled water. In this condition the soil was occasionally agitated during four weeks, when the contents of the flask were transferred to a funnel whose stem fitted air-tight one neck of a Woulff's bottle, while the other was so arranged that it could be connected with an air pump, and in this manner a pressure was developed which caused percolation into the bottle.

Eichhorn used a garden soil, from near Bonn, Prussia, which had not been recently manured, and to this he added 36.5 per cent of its weight of distilled water, allowing it to remain during ten days before withdrawing the solution.

The sample with which Wunder worked was a rather poor field soil having a capacity for about 15 bushels of wheat per acre, and was taken from the farm of the Chemnitz Experiment Station, Saxony. Below are the results obtained by these two investigators:

Salts recovered with water and with hydrochloric acid (Wunder and Eichhorn, 1860).

[In parts per million of dry soil.]

WITH WATER.

Investigator.	Potash.	Lime.	Magnesia.	Soda.	Oxide of iron and alumina.	Phosphoric acid.	Sulphuric acid.	Silica.
Wunder (16)	7.5	83.6	37.4	30.4	11.7	Trace.	....	25.7
Eichhorn (17)	115.4	128.0	38.4	11.0	Trace.	31.0	100.2	48.0

WITH HYDROCHLORIC ACID.

Wunder	1,250	3,800	1,000	2,060	64,000	1,400	540	1,100

Dr. Franz Schulze,[b] working in still a different manner with special reference to the amount of phosphoric acid which may be recovered from soils with distilled water, repeatedly washed the same sample and examined the separate extracts for phosphoric acid.

The apparatus he used may be described in its essential features as follows: A three-necked 2-liter Woulff's bottle had its middle neck fitted with a glass cylinder provided with a funnel-shaped contraction at the lower end, and a ground-glass, air-tight joint. The cylinder, at the bottom, was loosely stopped with a clean sponge on which was a layer of coarse sand with other layers of sand grading in fineness to the upper very fine one. The sands had been ignited and then

[a] Die Landwirthschaftlichen Versuchs-Stationen (1860), pp. 104–112.

[b] Die Landwirthschaftlichen Versuchs-Stationen (1864), Vol. VI, p. 409.

extracted with hydrochloric acid to render them free from readily soluble matters. Upon this filter, in the cylinder, was placed 1,000 grams of air-dry and well-pulverized soil. When the apparatus was filled with the soil to be extracted the water was added and the air exhausted by means of an air pump connected with one neck of the bottle, thus developing pressure which forced the filtration. In this manner six successive liters of water were forced through the soil, one liter of extract being obtained in each twenty-four hours.

Four consecutive liters of one solution obtained in this manner gave, on evaporation, 0.645 gram of residue, when dried at 110° C. This, on ignition in the air, lost 0.290 gram, and the ignited residue contained the amounts given in the next table, expressed in parts per million of dry soil:

Obtained from 1,000 grams of soil in 4 liters of solution (Schulze, 1864).

[In parts per million of the dry soil.]

	Potash.	Lime.	Magnesia.	Soda.	Phosphoric acid.	Nitric acid.	Carbonic acid.	Chlorine.	Silica.	Organic matter.
(18)	37.6	105	25	22	22.4	29	34.7	65.1	12.5	290.0

In the next table are given the results of an experiment conducted with special reference to the amounts of phosphoric acid which might be recovered in successive liters of a filtrate:

Phosphoric acid recovered by successive percolations of water (Schulze, 1864).

No. of filtrate.	Weight of evaporated residues.	Weight of ignited residues.	Phosphoric acid (P_2O_5).
	Grams.	*Grams.*	*Grams.*
1	0.535	0.195	0.0056
2	.120	.063	.0082
3	.261	.160	.0088
4	.203	.120	.0075
5	.260	.178	.0069
6	.200	.123	.0044
Sum	1.579	.839	.0414

There were thus recovered from this soil 41.4 parts of phosphoric acid per million of the dry soil during six days of percolation through the action of 6 liters of water.

In describing this soil Doctor Schulze says in substance that it was taken from a field near the city of Goldberg, in Mecklenberg, and is comparable with the Russian "Tschernosem" in its lasting fertility and physical characters. On ignition the loss was 5.5 per cent of the soil, dried at 110° C.; its content of humus was a little above 4 per cent as a mean of 4 determinations (calculated from CO_2 formed by combustion); the relation of weight of sand to finest sand, clay, and finest silt is almost exactly as 2 to 1; the water capacity was 42 per

cent. The total nitrogen amounted to 0.204 per cent, and from 100 parts of soil, heated with access of air, boiling strong hydrochloric acid extracted: 2.16 parts iron oxide, 1.84 alumina, 0.10 manganese oxide, 2.42 lime, 0.308 magnesia, 0.068 potash, 0.075 soda, 0.081 sulphuric acid, 0.285 phosphoric acid.

E. Hayden,[a] also working to test the solubility of phosphoric acid in water, caused enough water to be added to 1,250 grams of soil to enable him to procure 2,500 cc of filtrate. Two soils and two subsoils were used, which gave the following results:

Amount of phosphoric acid recovered by use of strong hydrochloric acid and by distilled water (Hayden, 1865).

Soil.	Soluble in strong hydrochloric acid, per cent.	Soluble in distilled water.	
		Per cent.	Parts per million of dry soil.
Surface soil A	0.137	0.0057	57
Subsoil A	.147	.0026	26
Surface soil B	.165	.0053	53
Subsoil B	.153	.0019	19

The data which have been presented in the most important of the foregoing tables are brought together in the following table:

Composition of water extracts from soils as found by different early observers (1858–1864).

[In parts per million of dry soil and pounds per acre-foot.]

No.[b]	Observer.	Potash.	Lime.	Magnesia.	Soda.	Oxide of iron and alumina.	Phosphoric acid.	Sulphuric acid.	Carbonic acid.	Chlorine.	Silica.	Organic matter.
1	Grouven	5.0	84.0	6.2	35.7	18.2	Trace.	15.2	92.0	0.7	199.2	101.0
2	do	69.0	234.0	16.0	46.0	......	14.0	9.0	110.0	15.0	384.0	306.0
3	do	89.0	173.0	30.0	76.0	12.0	52.0	57.0	90.0	27.0	135.0	217.0
4	E. Peters	25.8	124.5	25.8	18.3	33.3	(?)	20.4	......	40.8	66.6	....
5	do	40.0	60.0	10.0	40.0	......	....	10.0	......	Trace.	20.0	230.0
6	do	(?)	70.0	10.0	(?)	......	....	Trace.	......	....	40.0	70.0
7	do	10.0	100.0	Trace.	20.0	......	....	10.0	......	Trace.	110.0	180.0
8	do	(?)	110.0	0	(?)	......	....	Trace.	......	....	80.0	170.0
9	V. Jarriges	30.0	50.0	25.0	55.0	66.0	Little.	Trace.	......	Little.	45.0	240.0
10	do	85.0	160.0	35.0	40.0	85.0	Trace.	Little.	......	Little.	85.0	790.0
11	do	100.0	700.0	55.0	55.0	25.0	More.	More.	......	More.	300.0	710.0
12	R. Hoffman	470.0	1,640.0	110.0	120.0	770.0	Trace.	3,020.0	......	330.0	Trace.	4,490.0
13	do	210.0	920.0	440.0	240.0	20.0	Trace.	110.0	......	Trace.	10.0	2,300.0
14	do	46.2	336.0	33.7	89.0	......	53.7	178.0	......	34.6	Trace.	700.0
15	do	21.0	10.0	24.0	9.0	......	Trace.	Trace.	......	Trace.	Trace.	332.0
16	Dr. Wunder	7.5	83.6	37.4	30.4	11.7	Trace.	....	......	....	25.7	....
17	Dr. Eichhorn	115.4	128.0	38.4	11.0	Trace	31.0	100.2	......	....	48.0	....
18	F. Schulze	37.6	105.0	25.0	22.0	......	22.4	....	34.7	65.1	12.5	290.0
	Average of all	85.15	282.67	51.19	50.41	104.12	13.32	220.60	81.68	36.66	86.72	741.73
	Omitting 12 and 13: Average	48.61	158.01	26.53	39.10	31.40	13.32	28.56	81.68	25.27	110.77	333.54
	Pounds per acre-foot	146	474	80	117	94	40	86	245	76	332	1,001

[a] Hoffman's Jahresbericht über die Agriculturchemie, 1865, p. 33.
[b] The numbers appearing here are those used in connection with the data appearing in the preceding tables.

In this table the second line of averages is obtained by omitting Nos. 12 and 13, which are more properly peats than soils and contain abnormally large amounts of soluble matter. The amounts per acre-foot in the last line of the table are computed on 3,000,000 pounds as the dry weight of an acre-foot of soil, and Nos. 12 and 13 have again been omitted.

Referring to the table it will be seen that the largest amount of water-soluble potash was recovered from No. 12, the Meronitz peat, 470 parts per million, or 0.047 per cent of the dry peat itself, which, taking the weight of dry peat soil at 50 pounds per cubic foot, would make the soluble potash something more than 1,000 pounds per acre. The smallest measured amount of potash in any soil represents about 15 pounds per acre for the surface foot, while the largest amount, omitting the peat, is 300 pounds per acre, the average being 146 pounds. The lime ranges from 30 pounds per acre to 2,100 pounds, with an average of 474 pounds in water-soluble form. The magnesia ranges from 19 pounds per acre to 165 pounds, with an average of 80 pounds, while the phosphoric acid ranges from a trace to 160 pounds per acre and an average of 40 pounds soluble in water. The observations of Schulze and Hayden, however, last cited and not included in the general table under consideration, give an average of phosphoric acid for their five soils, of 39.28 parts per million of the dry soil, or 118 pounds per acre-foot of 3,000,000 pounds of dry soil.

COMPOSITION OF FIELD DRAIN WATERS.

Observations of Way, Voelcker, and Frankland.

It is a matter of much importance in this investigation to learn the composition of waters which have percolated through the soils of cultivated fields into drains; for, while they do not furnish data by which either the concentration of soil solutions or the amounts of salts actually in solution at any time may be computed, such data do show not only the character and magnitude of the fertility lost in this way, but they set the lower limit of the strength of the soil solution. They also show that the solution which actually invests the absorbing surfaces of the roots of growing crops is stronger to an undetermined degree than the drain water.

In the following table are given, in altered form, some of the determinations of drain waters made by Voelcker, Frankland, and Way:

Average contents of drainage waters from cultivated fields (Voelcker, Frankland, and Way).

[In parts per million of drain water.]

Contents.	Under wheat, 12 fields.[a]	Under wheat, 3 fields.[b]	Under hops, 4 fields.[b]	Average.
Organic matter	32.66	87.13	118.20	79.33
Ammonia	.19	.22	.21	.21
Potash	3.07	.35	.85	1.42
Lime	159.33	45.87	114.23	106.48
Magnesia	7.34	6.17	29.45	14.32
Soda	14.46	15.37	32.25	20.69
Oxide of iron and alumina	4.27	8.13	3.55	5.32
Nitric acid	62.24	59.83	167.68	96.58
Phosphoric acid	.95	.37	1.43	.92
Sulphuric acid	71.32	22.10	79.15	57.52
Carbonic acid	53.52	....	....	53.52
Chlorine	24.71	13.20	22.20	20.04
Silica	17.88	18.77	8.90	15.18
Sum	451.94	277.51	578.10	471.53

[a] By Voelcker and Frankland. Rothamsted Memoirs, Volume V, Composition of Rain and Drainage Water, p. 91.
[b] By Way. Journal Royal Agricultural Society, Volume XVII, p. 133.

The following tables show the fertilizers annually applied to the plots of the Broadbalk Fields from which the drainage waters of the first column of the last table were collected:

Fertilizers annually applied to plots in Broadbalk Fields.

Plot.	Fertilizers applied annually.
2	14 tons farmyard manure.
3 & 4	Unmanured.
5	Mixed mineral manure.[a]
6	200 pounds ammonium salts, and mixed minerals.[a]
7	400 pounds ammonium salts, and mixed minerals.[a]
8	600 pounds ammonium salts, and mixed minerals.[a]
9a	550 pounds nitrate of sodium, and mixed minerals.[a]
9b	550 pounds nitrate of sodium, alone.
10	400 pounds ammonium salts, alone.
11	400 pounds ammonium salts, and superphosphate.
12	400 pounds ammonium salts, and sulphate of sodium.
13	400 pounds ammonium salts, and sulphate of potassium.
14	400 pounds ammonium salts, and sulphate of magnesium.

[a] The mixed mineral manure contains in every case 3½ hundredweights of bone-ash superphosphate, 200 pounds of commercial sulphate of potassium, 100 pounds of sulphate of sodium, and 100 pounds of crystallized sulphate of magnesium per acre. An increased amount of the sulphates of sodium and magnesium is applied to plots 12 and 14, the quantities of the two sulphates being respectively 366½ and 280 pounds.

Fertilizing ingredients applied to Broadbalk Field annually, and crop yields. [a]

[In pounds per acre.]

	Plot 2.	Plots 3 & 4.	Plot 5.	Plot 6.	Plot 7.	Plot 9.	Plot 10.	Plot 11.	Plot 12.	Plot 13.	Plot 14.
Potash	235	....	100	100	100	50	....	....	....	100	.....
Soda	31	....	41	41	41	212	....	1	147	1	1
Lime	31	....	86	86	86	43	....	86	86	86	86
Magnesia	35	....	18	18	18	9	....	2	2	2	47
Phosphoric acid	78	....	64	64	64	32	....	64	64	64	64
Sulphuric acid	47	....	265	321	376	132	111	208	397	293	298
Chlorine	38	....	....	60	119	7	119	119	119	119	119
Nitrogen	201	....	....	43	86	86	86	86	86	86	86
Total	696	....	574	733	890	571	316	566	901	751	701
Total yields	5,304	1,726	1,984	3,348	5,013	6,920	3,587	3,716	4,493	4,964	4,716
Yield of grain	1,890	675	675	1,215	1,688	2,175	1,080	1,350	1,590	1,703	1,673

[a] Rothamsted Memoirs, Vol. V, Composition of rain and drainage water, p. 88.

In the foregoing table the fertilization of the plots has been stated definitely in pounds per acre of each ingredient actually applied except that, in case of plot No. 2, the amounts are approximate.

In the next table are given the data obtained by Voelcker from the different drainage waters whose averages have been given in the first column of the table at the top of page 23:

Contents of drainage water from Broadbalk Field, Rothamsted (Voelcker).[a]

[Contents given in parts per million of drain water.]

Contents.	Plot 2.	Plots 3 & 4.	Plot 5.	Plot 6.	Plot 7.	Plot 9.	Plot 10.	Plot 11.	Plot 12.	Plot 13.	Plot 14.
Total solids	476.1	246.4	326.0	407.6	492.4	423.9	406.9	425.9	530.9	544.3	598.6
Oganic matter	26.1	22.9	19.3	25.7	34.9	26.7	33.6	38.4	29.3	45.3	56.1
Nitrogen as nitric acid	16.1	3.9	5.1	8.5	14.0	18.4	13.9	15.3	15.1	17.4	19.2
Nitrogen as ammonia	.16	.12	.13	.20	.07	.24	.08	.17	.3	.16	.09
Lime	147.4	98.1	124.3	143.9	181.4	118.1	154.1	165.6	191.6	201.4	226.7
Magnesia	4.9	5.1	6.4	7.9	8.3	5.9	7.4	7.3	6.6	9.3	11.6
Potash	5.4	1.7	5.4	4.4	2.9	4.1	1.9	1.0	2.7	3.3	1.0
Soda	13.7	6.0	11.7	10.7	10.9	56.1	7.1	6.6	24.6	6.1	5.6
Oxide of iron	2.6	5.7	4.4	2.7	8.1	5.1	4.0	3.4	3.6	3.7	3.7
Chlorine	20.7	10.7	11.1	20.7	26.1	12.0	32.0	31.6	30.9	36.6	39.4
Sulphuric acid	106.1	24.7	66.3	73.3	90.1	41.0	44.4	54.3	96.7	86.9	99.7
Phosphoric acid	......	.63	.91	1.54	.91	......	1.44	1.66	1.26	1.09	1.01
Carbonic acid	43.3	48.1	44.4	59.0	58.0	73.0	45.4	44.9	64.6	51.1	56.9
Silica	35.7	10.9	15.4	24.7	17.0	10.6	10.9	11.3	17.9	28.3	14.0

[a] Rothamsted Memoirs, Vol. V, Composition of rain and drainage waters, p. 91.

The drainage waters examined by Way were collected on December 26 and 27, 1855, at the beginning of the first percolation following a considerable interval of no discharge, the drains having a depth of 4 to 5 feet. The rainfall is described as one-half an inch coming during the night of the 24th, when the ground was frozen at the surface, another half inch falling between the night of the 25th and the afternoon of the 26th. It should be observed here that the samples of water collected for Way, at least those on the 26th, were not composed of the rain which had fallen at the time but rather of the moisture already existing in the soil which was forced out ahead of the water which had fallen as rain.

The fertilization of the fields had been as follows:

Wheat field (1) was manured for turnips in 1852 with dried blood or guano and superphosphate, having previously been limed at the rate of 160 bushels per acre. The turnips were fed off with sheep fed with oil cake and hay, and wheat was grown in 1853. Turnips were grown without manure in 1854; in 1854–55, wheat, with 4 hundredweight of guano; and, at the time of collecting the water, the field was again in preparation for turnips.

Wheat field (4) had been given, in the autumn of 1854, 4 hundredweight of guano in preparation for the following crop of wheat; prior to this it had been manured for some years with guano or dried blood and superphosphate of lime and had been limed at the rate of 160 bushels per acre four years before.

Wheat field (5) had been in poor condition and was manured in 1853 with dried blood and superphosphate for turnips; the turnips were fed off with sheep receiving oil cake and the ground was sown with wheat in the spring of 1854. It was again sown with wheat at the time the samples were taken and had received 4 hundredweight of guano per acre.

Hop field (2) was drained in 1852–53 and given 5 hundredweight of guano and 5 hundredweight of superphosphate per acre; in 1854, 15 hundredweight of horn shavings and 200 bushels of lime per acre; in 1855, 20 hundredweight of rabbit-skin waste and 3 hundredweight of guano per acre.

Hop field (3) previous to 1853–54 had been a poor commonage pasture; it was given in 1854 6 hundredweight of guano and 6 hundredweight of superphosphate; and in 1855 30 hundredweight of rags per acre.

Hop field (6) had been in this crop for some twenty-five years and was in the "richest possible condition," having received 30 tons of good dung, or 30 hundredweight of rags or hair each year. The last year it had received 40 tons of manure per acre.

Hop field (7) was planted with hops in 1846 and had been abundantly manured each year thereafter, receiving in 1855 15 hundredweight of horn shavings and a good dressing of silicate of lime.

The data from the individual fields in this series appear in the following table:

Composition of drainage water from wheat and hop fields well manured (Way).

[Water contents in parts per million of drain water.]

Contents.	Wheat field 1.	Hop field 2.	Hop field 3.	Wheat field 4.	Wheat field 5.	Hop field 6.	Hop field 7.
Potash	Trace.	Trace.	0.30	0.70	Trace.	3.1	Trace.
Soda	14.3	31.0	32.3	12.4	20.3	20.0	45.7
Lime	69.3	102.4	86.4	32.3	36.0	83.1	185.0
Magnesia	9.7	33.1	35.4	5.8	3.0	13.3	35.7
Oxide of iron and alumina	5.9	.7	1.4	None.	18.5	5.0	7.1
Silica	13.5	6.4	7.8	17.1	25.7	9.3	12.1
Chlorine	10.0	15.7	18.4	11.6	18.0	17.3	37.4
Sulphuric acid	23.5	73.5	62.8	24.4	18.4	44.5	135.8
Phosphoric acid	Trace.	1.7	Trace.	Trace.	1.1	.9	1.7
Nitric acid	102.4	210.5	181.7	27.8	49.3	115.0	163.5
Ammonia	.25	.25	.25	.17	.25	.25	.09
Organic matter	100.0	105.7	178.5	80.0	81.4	82.8	105.7
Total	348.9	581.0	605.3	222.3	272.0	394.6	729.8

THE AMOUNTS OF SOLIDS IN SOLUTION IN THE SOILS OF THE BROADBALK FIELD.

There appears to be no reason to doubt, when an average is taken, that the water draining away from a field is at least not stronger than that retained in the soil. We may, therefore, use the data of the preceding tables to compute an under limit for the amounts of dissolved plant food carried in the soil at the time when it is sufficiently saturated to cause percolation into tile drains to take place. The authors of the paper here considered give the amounts of water in the surface 3 feet of three of the plots, when in the state of winter saturation, as 1,610, 1,360, and 1,549 tons, or an average of 1,506.3 tons per acre. Taking 1 ton as 2,000 pounds, the amount of water per acre in the surface 3 feet is, in round numbers, 3,000,000 pounds. If, therefore, the values in the table on page 24 are multiplied by 3, the results will express pounds per acre for the surface 3 feet; moreover, the figures as they stand represent, approximately, the pounds per acre for each foot of depth.

On this basis the total solids in solution, in the surface foot of soil of the Broadbalk Field, range from about 250 pounds, on plots 3 & 4, to about 600 pounds on plot 14, the average of all the plots being 452 pounds, or, for the 3 feet, 1,356 pounds, which is considerably less than the mean amount added each year, supposing everything added were soluble in water and remained so.

Relation Between the Amounts of Fertilizers Added and Total Solids in the Drainage Water.

If the 16 Rothamsted plots under consideration are arranged in the order of the total fertilizers added to the respective areas, and the total solids in the drainage water are grouped to correspond, they will appear as shown in the following table, where there are also given, in the last column, the differences between the total solids in the drainage waters from the fertilized and the mean from the unfertilized plots:

Relation between the amounts of fertilizers added and the total solids in the drainage waters.

No. of plot.	Fertilizer added.	Total solids in drainage water.	Excess of salts from fertilized plots.
	Pounds per acre.	*Parts per million.*	*Parts per million.*
8	1,049	548.4	282.1
12	901	530.9	237.3
7	890	492.4	225.8
15	832	585.3	318.7
13	751	544.3	277.7
6	733	407.6	143.0
14	701	598.6	332.0
2	696	476.1	209.5
5	574	326.0	54.9
9	571	423.9	157.3
11	566	425.9	159.3
10	316	406.9	140.3
16	0	286.7	....
3 & 4	0	246.4	....

AMOUNTS OF SOLUBLE SALTS IN FRESH FIELD SOILS READILY RECOVERABLE WITH DISTILLED WATER.

During investigations relating to the development and loss of nitrates in field soils, covering three years just prior to taking up the present work, it was learned that if a knowledge is desired of the amounts of nitrates in a soil at the time the samples are taken, the examination must be made at once. It will not do to allow either the soil or the solution prepared from it to stand overnight, for then nitrification is very certain to take place in the soil and denitrification in the solution, and these changes are much larger than the errors of observation, and too large to be ignored in an investigation of this character. Since measurable changes in the amounts of nitrates in a soil may be expected to be associated with changes in other soluble ingredients of a soil, it appears imperative, in undertaking a comparative study of this sort, to work rapidly with fresh samples direct from the field; and it was

on this account, among others, that we sought the use of methods having the order of dispatch, delicacy, and accuracy which the method for the determination of nitric acid possesses. Furthermore, it was desired to test the feasibility of an improvised laboratory in the field, near a number of soil types and field conditions, in order to further reduce delay and to bring the work in immediate touch with the field. The results recorded further on (pp. 38–58) were obtained at Goldsboro, N. C., during the summer of 1902, in a laboratory set up in a cotton field adjacent to a water main, where the city supply was available.

Procuring Samples of Soil.

In a preliminary investigation, in which the movements of the water-soluble salts in the soil were to be investigated as well as the character and amounts of them, it was thought necessary to extend the observations to a considerable depth; it was, therefore, decided to

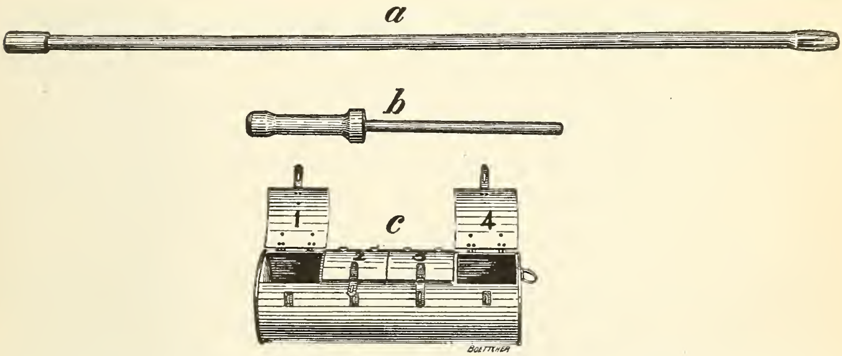


Fig. 1.—Apparatus used in procuring soil samples: *a*, Soil tube of $\frac{1}{16}$-inch brass 5 feet long, inside diameter 1 inch, provided with an iron head, and with a steel point tempered for stone and having an inside diameter of $\frac{7}{8}$ inch; *b*, mallet of iron weighing 8 pounds with stem 14 inches long for insertion into the tube—used in driving the tube into the soil; *c*, collecting case having four compartments with hinged lids.

work to a depth of 4 feet, because the water content changes measurably to this depth under crops, and because, when the soil is in proper physical condition, the roots of many, if not most, crops penetrate to this depth.

Unless otherwise stated, the soil samples were taken out in 12-inch sections and were designated first, second, third, and fourth foot, respectively. The soil tube (fig. 1, *a*), cutting a core seven-eighths of an inch in diameter, was used in taking all samples; and each sample is a composite of 4 cores procured from typical and comparable places. The cores of soil, when withdrawn, were transferred to a cylindrical collecting case divided into 4 compartments, each provided with a separate hinged lid (fig. 1, *c*). The tube is driven into the soil by means of the iron mallet (*b*), weighing about 8 pounds, provided with a stem 14 inches long, which slides freely up and down in the top of the soil tube.

The procuring of comparable soil samples is a matter of the utmost importance in an investigation of this sort, and can only be done when great care and the best judgment are exercised. It has been found that samples of soil taken from single places in a field, even when not very far apart, often differ in water content by as much as 2 per cent or more, even when the best judgment has been exercised in selecting comparable localities. It has been found, too, that where the water content varies materially there may also be variations in the amounts of recoverable water-soluble salts; but when not less than 4 cores are combined in a single composite sample, duplicates can be taken which agree, usually, within 0.6 per cent or less in the water content.

When the surface of the field has been left furrowed, as happens in cultivating, even when the furrows are shallow, and a rain has recently occurred of such a character that it collects in the furrows, very different results will be obtained in the amounts of water-soluble salts when the samples are taken from the ridges and from the furrows between them. This is true even when only 3-inch shovels have been used, and the irregularities of distribution due to this cause often extend through fully 4 feet in depth, as the writer and Prof. A. R. Whitson[a] have conjointly demonstrated, one measuring the nitrates by the chemical method and the other the total salts by the electrical method. The observations referred to were made to ascertain if there was a measurable variation in the distribution of soluble salts under and between rows of corn when just in full tassel. Four series of samples had been taken, consisting of ten cores each, along parallel lines 6 inches apart, beginning with the row of corn. By a pure coincidence it happened that two of these series of samples were taken in the bottoms of the slight furrows left by the 3-inch cultivator shovels, while the others fell on the ridges between them. As the field had received what is called "flat cultivation" it had not occurred to us that such a slight ridging of the surface could exert a disturbing influence on our results; but when each of us had tabulated our data and compared them we were astonished at the systematic differences found and at the concordance between the two sets of observations. There had been a considerable rainfall, which fell rapidly, three days before the samples were taken. The amounts of salts found in the surface 6 inches are given below:

Amounts of salts found under ridges and furrows in a Wisconsin field.

[In parts per million of dry soil.]

Salts.	Under hill.	Under first furrow.	Under next ridge.	Under second furrow.
Nitrates	17.67	9.04	15.16	8.39
Total salts	100.10	80.30	98.50	79.70

[a] Bulletin 85, Wisconsin Agricultural Experiment Station, p. 30.

It is to be observed that here are four sets of samples taken along lines only 6 inches apart, yet differing in recoverable water-soluble salts quite as much as notably different soils do. This field was sampled at the time to 7 depths extending to 4 feet, and in each and every level the effect which the cultivation and the rain had had was distinctly measurable, and is shown graphically in the bulletin referred to.

Attention is called to this matter here specially for two reasons: (1) To emphasize how important it is in such work that great care be exercised in taking soil samples, and (2) to show that even under such complex conditions when due care is exercised differences become measurable which would generally be regarded as impossible of detection. It is quite probable that had we not taken the precaution to make our samples in every case composites of 10 cores such concordant results throughout the long series would not have been secured.

In the series of investigations (1902) to be discussed the soil samples were all taken in the morning, the clear soil extracts were obtained from them before noon, and all determinations were completed on the same day.

As it is the general practice at Goldsboro to apply fertilizers, even in the case of stable manure, under the rows, and as ridge cultivation is also practiced for intertilled crops, soil samples were usually taken under the rows.

Preparation of the Soil Extract.

In preparing the soil extract the cores of the soil sample were well broken down and thoroughly mixed in a granite-ware basin. Two 100-gram samples were then weighed out on a Springer torsion balance, one being transferred to a Wedgwood mortar and the other to the dry oven for moisture determinations. In a graduated flask 500 cc of distilled water were measured out, and enough was added to the sample in the mortar to work it into a thick paste with the pestle, breaking down the granulations, when the balance of the water was added and the whole stirred continuously with the pestle during three minutes. The supernatant turbid liquid was then transferred to a pint Mason jar and from here, usually inside of fifteen minutes, to the filter chambers, a set of which is represented in figure 2. By means of compressed air in the reservoir the solutions were filtered, under a pressure of about 30 to 40 pounds, through Chamberland-Pasteur filters, and perfectly clear extracts obtained in from five to twenty minutes, depending upon the character of the soil or the amount of fine sediment remaining suspended in the solution to be deposited upon the walls of the filters. It will be noted that the time of stirring—three minutes—refers simply to the interval of vigorous agitation of the soil in the solution when rapidly changing contact is maintained, while the actual time of contact of a portion of the solution with some

portion of the soil sample may have been as great as thirty minutes with some samples; but it is known from definite observation that the chief part of the solution is accomplished during the three minutes of vigorous agitation.

The adoption of these particular time limits in preparing the solutions was the result of several considerations: (1) It was desired to procure, as nearly as possible, the materials which were in actual solution in the soil at the time, which it was reasoned would be accomplished by simply diluting as quickly as possible the moisture already present, and then separating a known portion of this diluted solution from the body of the soil with all practicable dispatch; (2) it was regarded as of greater importance to obtain results strictly comparable among themselves than to secure those which would have absolute values; (3) the

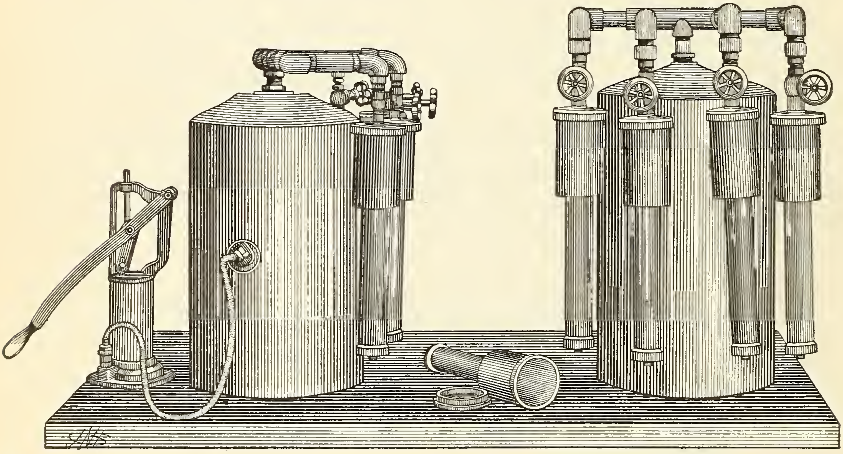


Fig. 2.—Front and side view of a battery of four filter chambers attached to a 7-gallon "expansion tank" which serves as a compressed-air reservoir. Compression pump is shown at the left.

time of vigorous stirring was made as short as consistent with permitting closely duplicate results on the same sample to be secured; it was found that this could be done with about three minutes' washing, and also that longer washing only slowly increased the amounts of materials taken into solution.

Preliminary Observations.

A series of the preliminary observations are cited here in illustration of the influence of the time of vigorous agitation on the strength of the solution. A quantity of soil from the Arlington Heights farm was screened and thoroughly mixed so that closely duplicate samples of it could be obtained. Four 100-gram lots of this soil were weighed out—(1) for moisture determination, (2) to be washed one minute, (3) to be washed two minutes, and (4) to be washed three minutes in 500 cc

of distilled water. The filtered portions of the solutions were examined at once for total salts by the electrical method, and by chemical methods for NO_3, Cl, and HCO_3, while the unfiltered portions were allowed to stand over night and were examined the following morning, four tests being made in each case. The results appear in the following table:

Influence of different intervals of washing on the composition of the soil extract.

[In parts per million of solution.]

Test No.	Time of washing.	Amounts obtained by—							
		Electrical method, total salts.		Chemical methods.					
				Nitrates.		Chlorides.		Bicarbonates.	
		At once.	Next morning.	At once.	Next morning.	At once.	Next morning.	At once.	Next morning.
1	One minute	23.25	32.08	2.148	....	8.1	....	5.0	....
2	.....do	24.60	26.80	2.171	....	8.8	....	5.0	....
3	.....do	24.60	26.80	2.125	....	6.6	....	5.0	....
4	.....do	25.75	27.93	1.964	....	7.4	....	5.0	....
	Average	24.55	28.40	2.102	1.584	7.72	7.4	5.0	4.6
5	Two minutes	26.46	32.58	2.772	....	7.4	....	4.6	....
6	.....do	26.30	32.62	2.772	....	7.4	....	4.6	....
7	.....do	28.37	31.55	3.187	....	7.4	....	10.0	....
8	.....do	26.34	33.01	3.280	....	6.6	....	5.0	....
	Average	26.87	32.44	3.003	1.408	7.2	7.4	6.05	4.6
9	Three minutes	29.77	33.33	3.233	....	7.4	....	10.0	....
10	.....do	25.40	32.56	3.326	....	6.6	....	4.2	....
11	.....do	29.98	32.56	3.303	....	7.4	....	7.9	....
12	.....do	29.77	32.56	3.326	....	7.4	....	7.5	....
	Average	28.73	32.75	3.297	1.540	7.2	7.4	7.4	4.6

As a result of these and other observations, the arbitrary period of three minutes for vigorous stirring was adopted in preparing the soil extracts.

As it appeared evident that, in case dissolved salts in the soil moisture and those which are readily soluble are carried into the interiors of the soil granules and are there concentrated about or precipitated upon the finest particles, the ordinary rapid washing would not be likely to remove these as completely as would be the case if the granular structure could first be broken down, observations were made upon this point. A series of eight 100-gram samples of the Plains Marl soil (No. 2809) was divided into 4 groups: (A) to be shaken with 500 cc of distilled water two minutes in a bottle; (B) to be rubbed dry in a mortar 2 minutes and shaken two minutes in a bottle; (C) to be rubbed dry four minutes in a mortar and shaken two minutes in a bottle, and (D) to be washed 2 minutes in a mortar. The results follow:

Influence of breaking down the soil granules upon the amount of salts recovered with water.

[In parts per million.]

Treatment.	Group.	Total salts.	Nitrates.	Bicarbonates.	Chlorides.	Silica and phosphates.
Shaken two minutes in bottle	A 1	74.47	0.990	77.60	0.58	14.78
	A 2	83.94	.968	90.95	.58	23.40
Average	....	79.21	.979	84.28	.58	19.09
Rubbed dry two minutes in mortar and shaken two minutes in bottle	B 3	90.89	1.078	99.29	.58	21.12
	B 4	90.89	1.056	98.45	.58	26.40
Average	....	90.89	1.067	98.87	.58	23.76
Rubbed dry four minutes in mortar and shaken two minutes in bottle	C 5	99.49	1.320	105.13	.58	26.40
	C 6	95.51	1.276	101.79	.58	26.40
Average	....	97.50	1.298	103.46	.58	26.40
Washed two minutes in mortar	D 7	83.91	1.023	89.28	.58	24.29
	D 8	80.45	1.034	86.77	.58	22.17
Average	....	82.18	1.029	88.03	.58	23.23

These results make it clear that the breaking down of the granular structure before adding the water materially increased the strength of the soil extract, and that working the soil with the water in the mortar gave larger results than did simply shaking in stoppered bottles. As it was desired, in the beginning at least, to work with perfectly fresh field samples, the method employed with the D samples was adopted, which permitted of rapid, effective puddling of the sample to be treated.

It was realized that, if the local well or river water of the locality could be used for obtaining the soil extract instead of distilled water, the details of the field laboratory would be simplified. Results of work in Wisconsin, however, indicated that this would probably not be admissible, but it seemed best to make a direct trial to see if permissible results might not be secured by a method of differences, and the following observations were made. Eight 100-gram samples of the Plains Marl soil (No. 2809) were washed, in the adopted manner, with 500 cc of hydrant water, a bulk quantity of which had been previously examined by the methods for soluble salts. The results were as follows:

Salts recovered by washing soil in hydrant water.

[In parts per million of solution.]

Sample number.	Total salts.	Nitrates.	Chlorides.	Bicarbonates.
1	114.66	6.490	3.48	97.62
2	116.77	6.820	3.48	102.63
3	118.20	6.490	3.48	100.96
4	116.23	6.600	3.48	101.79
5	114.34	6.710	3.48	101.79
6	116.35	6.600	3.48	100.96
7	116.82	6.820	3.48	102.63
8	116.02	6.820	3.48	102.63
Average	116.17	6.669	3.48	101.38
Salts in hydrant water used	64.53	5.830	3.48	72.59
Difference	51.64	.839	0.00	28.79
Amount with distilled water	74.43	.908	0.00	74.26

It thus appears that, except with the chlorine, the differences do not correspond with the amounts found with distilled water, and for this reason all soil extracts have been prepared with distilled water.

The Amount of Water Used.

While it is stated that we have prepared our extracts with distilled water, it is, of course, only true that the water was pure at the beginning of the treatment: for, with its progress, more and more of the salts were dissolved from the soil so that each treatment closed with a complex solution similar to well or river water, such as it has just been shown it was inadmissible to use. There appears to be no way of avoiding this difficulty, and the only alternative is to reduce the error as much as possible. This was done by adopting the ratio of water to soil which would give as dilute solutions as it was safe to use with the methods. The results of 6 trials upon this point follow. Of the 6 trials made, 4 were on one soil and 2 on another.

Differences in amounts of salts recovered by using different ratios of water to soil.

[In parts per million of dry soil.]

Soil and treatment.	NO_3.	SO_4.	HPO_4.	HCO_3.	Cl.	SiO_3.
First soil—4 trials:						
100 grams washed in 500 cc	9.90	25.74	2.71	19.68	10.55	28.24
Do	9.55	28.32	2.71	16.65	8.78	28.70
Average	9.725	27.03	2.71	18.165	9.665	28.47
400 grams washed in 1,000 cc	7.78	18.15	3.65	21.20	10.55	28.44
Do	8.22	18.62	2.30	18.17	8.80	30.44
Average	8.00	18.385	2.975	19.685	9.675	29.44
Second soil—2 trials:						
100 grams washed in 500 cc	17.55	49.11	6.02	24.22	7.04	13.62
400 grams washed in 1,000 cc	19.58	41.00	4.06	10.60	5.28	13.35

These results, while not wholly consistent, show clearly the tendencies and some of the many difficulties which are encountered in such investigations.

Preparation of Plant Extracts.

In the preparation of plant extracts for the work here reported the samples were always taken at the places where the soil samples were procured, and at the same time, in order that the observed soil and plant data might be as definitely related as possible. The plants were cut up when fresh, care being taken to avoid wilting, into fine pieces, to permit of reliable sampling. Then 100 grams were dried for moisture determination, and 20 grams were transferred at once to the mortar and thoroughly crushed with the pestle, after which 500 cc of distilled water were added. The whole was stirred with the pestle during three minutes, and the solutions were decolorized and filtered.

Rendering Solutions Colorless.

It is a matter of the utmost importance in all work of this character that the solutions shall not only be *perfectly clear*, but also *entirely*

free from color. Extracts prepared from most *fresh* soils are very nearly or quite colorless, but from samples which have been dried they are usually, and from plant extracts always, colored and must be decolorized before they are used. This can be quite satisfactorily accomplished with the aid of "G Elf Carbon Black." It does not measurably affect the extract, either by the addition of impurities or by the fixation of the materials in solution which have been determined. The use of 3 to 5 grams of this carbon black to 100 grams of soil, or to 20 grams of green plant, will usually render the solution colorless after standing 15 to 20 minutes with frequent agitation.

Determination of Soluble Salts.

The methods used in these determinations have been described in a general way in Bulletin 22 of this Bureau, and for purposes of this discussion the necessary working details may be omitted here.

During the first season's work (1902) none of the bases were determined in any of the soil or plant extracts and only the amounts of the negative radicals NO_3, HPO_4, SO_4, HCO_3, Cl, and SiO_3 were investigated. These have all been expressed quantitatively in parts per million of the dry soil, or in parts per 4,000,000 wherever the sums of the parts per million in the first, second, third, and fourth feet have been used.

It should be said in explanation of the particular method of expressing the results that when the field work was begun there was little immediate prospect of available methods for the estimation of any of the bases, but it was believed by the Bureau that, with the aid of the electrical method, the total salts in the soil extracts could be determined. With this in view the electrical resistance of all extracts examined during the season of 1902 was measured and Doctor Cameron's advice was followed in expressing the results, it being thought that the method adopted would be best suited to a comparison of the results of the two classes of data.

Sensitiveness and Reliability of the Methods.

It should be said in regard to these methods that they have been chosen for the work undertaken (1) because of their sensitiveness and the possibility of securing results with them on small quantities of the soil extract, and (2) because of the rapidity and facility with which results are obtainable with them, these being at once available on the day the samples are procured.

Methods which require the use of large volumes of soil extract increase enormously the difficulties of such investigations as have been here undertaken so that, while gravimetric methods are undoubtedly more reliable from the standpoint of measurement, the difficulty of

controlling conditions and the danger of changes occurring after the determinations are begun are so great that mere quantitative accuracy after a solution has been obtained can not be permitted to determine the choice of method. Enough has already been said to show that the greatest difficulties and the greatest and most numerous sources of error are connected with the procuring of the extract for analysis, and it should be understood that these difficulties can not be avoided by gravimetric methods. Even the official methods of soil analysis, so far as procuring the soil extract is concerned, can not be said to be wholly free from them.

In the table which follows there are given duplicate analyses of the same set of samples made on three different dates for the purpose of determining the effect of allowing the samples to stand in Mason jars after they had been collected:

Duplicate analyses of the surface 4 feet of soil made on three dates and on the same samples of Selma silt loam, Goldsboro, N. C.—1902.

[In parts per million of dry soil.]

SURFACE FOOT.

Date.	Analysis.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_3.
July 9	First	18.50	7.47	36.30	7.36	18.64	3.59
	Second	18.72	7.20	36.90	6.69	20.24	3.60
July 14	First	28.65	7.47	43.20	4.01	18.64	3.07
	Second	25.90	6.72	41.60	4.01	20.20	3.25
July 19	First	36.10	8.22	38.40	2.67	13.98	3.95
	Second	35.60	8.59	39.00	2.67	13.98	3.78

SECOND FOOT.

Date.	Analysis.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_3.
July 9	First	9.98	7.98	33.70	5.71	14.98	3.84
	Second	9.61	7.20	33.70	5.71	11.65	3.85
July 14	First	9.06	7.18	37.70	5.71	18.30	4.03
	Second	9.08	6.47	38.80	4.34	15.14	4.27
July 19	First	10.56	7.98	35.40	2.86	13.31	3.06
	Second	10.40	8.38	35.40	3.57	11.65	2.88

THIRD FOOT.

Date.	Analysis.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_3.
July 9	First	11.28	6.65	11.71	4.46	15.56	3.99
	Second	10.90	6.65	11.71	3.72	20.75	3.99
July 14	First	10.36	5.77	17.99	4.46	18.86	5.36
	Second	9.92	4.96	17.45	2.96	17.17	5.56
July 19	First	12.90	9.84	22.00	1.47	18.86	5.56
	Second	12.04	9.45	20.80	2.21	20.46	5.75

FOURTH FOOT.

Date.	Analysis.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_3.
July 9	First	8.45	6.47	6.84	2.90	10.09	1.36
	Second	8.88	7.30	7.41	2.17	15.14	1.36
July 14	First	9.00	4.85	9.68	4.34	20.19	3.31
	Second	8.66	4.85	10.26	2.90	18.50	3.69
July 19	First	9.28	8.49	9.69	Acid.	11.78	2.91
	Second	9.28	8.49	9.69	Acid.	13.46	3.11

A comparison of each pair of analyses, which should be exact duplicates of each other, will show the character and magnitude of the variations which have occurred with the several methods as used. It should be understood that each value in the table is influenced by all of the conditions which affect any determination except the taking of the sample from the field.

Taking 4,000,000 pounds as the dry weight of an acre-foot of soil, the extreme variation between any two duplicate determinations for nitric acid amounts to 11 pounds per acre, while the mean difference is 2.16 pounds per acre. In the case of the phosphoric acid the largest difference between any two duplicate determinations is 0.83 part per million of dry soil, representing 3.32 pounds per acre. The mean difference here for the phosphoric acid expressed in percentage is about 6 per cent, which from some standpoints is large. The greatest irregularities occur in the determinations of chlorides and bicarbonates. The essential point to be emphasized is that the errors, judged from the standpoint of duplication, are much less than the differences which occur in the different soils, and that therefore the methods may be safely used to discover the general trend of many sets of conditions about which we are in great need of more information. The methods employed are exploration or reconnoissance methods, whose purpose is to discover and hew problems out in the rough and then leave them to be finished by methods of great refinement.

WATER-SOLUBLE SALTS IN THREE SOIL TYPES OBSERVED DURING THE GROWING SEASON.

Description of Soils and Conditions.

Beginning with April, 1902, and continuing until September 25, observations were made at intervals of one to four weeks on the amounts of water-soluble salts carried in the surface 4 feet of three soil types situated in the immediate vicinity of Goldsboro, N. C. The types chosen for this investigation were those designated and mapped by the Bureau as Selma silt loam, Norfolk sandy soil, and Goldsboro compact sandy loam. Their type characteristics are described on pages 193, 196, and 198 of Field Operations of the Division of Soils, 1900. They are characterized as follows:

Selma silt loam is a gray silty loam mixed with fine sand 18 inches deep, overlaying a mottled yellow clay subsoil, which sometimes contains fine sand and small gravel.

Norfolk sandy soil varies from a coarse, sharp, gray, sandy soil to a gray, sandy loam, 10 to 20 inches deep, overlying a yellow clay; the one chosen represents the medium condition.

Goldsboro compact sandy loam is a soil which comprises several variations in texture, all consisting, however, of gray, ashy, sharp, generally compact sand. Usually it has no distinct subsoil.

It had been our purpose to have both chemical and mechanical analyses made of the soils from the specific localities under investigation, but we are only able to cite type mechanical analyses from the above report.

Mechanical analyses of soils.

Soil and record number.	Organic matter and loss.	Gravel, 2–1 mm.	Coarse sand, 1–0.5 mm.	Medium sand, 0.5–0.25 mm.	Fine sand, 0.25–0.1 mm.	Very fine sand, 0.1–0.05 mm.	Silt, 0.05–0.005 mm.	Clay, 0.005–0.0001 mm.
Selma silt loam:	*Percent.*	*Percent.*	*Percent.*	*Percent.*	*Percent.*	*Percent.*	*Percent.*	*Percent.*
Surface soil, No. 5237	1.52	8.72	23.92	12.82	26.62	11.90	13.25	3.72
Subsoil, No. 5238	2.65	10.21	14.66	11.62	17.70	9.68	11.57	21.26
Norfolk sandy soil:								
Surface soil, No. 5229	.76	8.56	22.23	12.13	33.73	10.88	9.08	3.30
Subsoil, No. 5230	4.68	8.90	12.38	5.39	15.10	8.08	15.67	29.81
Goldsboro compact sandy loam:								
Soil, No. 5250	3.09	31.68	23.38	7.22	9.22	4.22	11.65	9.37

The mean effective diameters of the specific soils under investigation, as determined by the aspirator method,[a] are given below:

Mean effective diameters of soil grains.

Soil and treatment.	First foot.	Second foot.	Third foot.	Fourth foot.
Selma silt loam:	*mm.*	*mm.*	*mm.*	*mm.*
Unpestled	0.02289	0.06859	0.05770	0.05250
Pestled	.01817	.02200	.01407	.02499
Norfolk sandy soil:				
Unpestled	.02831	.05702	.06792	.06223
Pestled	.01841	.01216	.01618	.01074
Goldsboro compact sandy loam:				
Unpestled	.04990	.09036	.09974	.08952
Pestled	.03223	.06503	.06971	.04185

The observations were all made upon soils under ordinary field conditions and treatment. We simply secured permission to enter the fields and procure samples when and where desired. The samples, for the whole season, were taken along parallel lines, crossing the rows, four soil cores being taken along a running distance of about 400 feet; the succeeding line of sampling being always about 6 feet from the one just preceding it.

The three fields had been fertilized under the rows at the time of planting—the cotton field, on the Norfolk sandy soil, with cotton-seed hulls and stable manure mixed, and the other two fields with cotton-seed meal and guano. Only moderate amounts of fertilizers had been applied, but the quantities could not be definitely stated for either field.

The rainfall of the season aggregated, between April 21 and September 25, 17.41 inches, distributed as follows: April, 0.55; May, 1.255;

[a] Principles and Movement of Ground Water, United States Geological Survey, XIX Annual Report, Volume II, p. 222.

June, 4.15; July, 4.865; August, 5.43, and September, 1.16 inches. The heaviest rainfall occurred on July 10—2.49 inches. Given by days, the record of rainfall stands as follows:

Rainfall at Goldsboro, N. C., 1902.

Date.	Rainfall.	Date.	Rainfall.	Date.	Rainfall.	Date.	Rainfall.	Date.	Rainfall.
	Inch.		*Inch.*		*Inch.*		*Inch.*		*Inch.*
April 29....	0.35	June 7.....	0.17	July 7.....	0.62	Aug. 5.....	.37	Aug. 21....	1.64
April 30....	.20	June 8.....	.88	July 10....	2.49	Aug. 6.....	.31	Aug. 27....	.48
May 2......	.16	June 15....	.06	July 12....	.02	Aug. 7.....	.03	Sept. 2.....	.01
May 8......	.25	June 16....	.04	July 15....	.88	Aug. 9.....	1.02	Sept. 8.....	.04
May 11....	.15	June 21....	1.27	July 21....	.31	Aug. 11....	.59	Sept. 9.....	.67
May 14....	.23	June 24....	.82	July 27....	.31	Aug. 14....	.29	Sept. 13....	.24
May 15....	.27	June 26....	.01	July 29....	.03	Aug. 16....	.47	Sept. 21....	.20
May 25....	.12	June 27....	.25	July 31....	.025	Aug. 19....	0.18		
May 27....	.075	June 28....	.65	Aug. 1.....	0.27	Aug. 20....	.02		

RESULTS OF DETERMINATIONS BY MONTHS.

In the three tables which follow, there have been brought together, by months, the amounts of the different water-soluble salts which were recovered from the 4 depths of 3 soil types by washing three minutes in distilled water.

Amounts of water-soluble salts in soil under potatoes on Selma silt loam, Goldsboro, N. C.—1902.

[Salts in parts per million of dry soil.]

Month.	Soil moisture.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_3.
IN SURFACE FOOT.							
	Per cent.						
April	14.70	41.15	12.72	144.98	30.80	52.44	8.47
May	10.51	22.70	6.57	62.84	12.03	17.40	5.53
June	7.53	24.10	12.50	79.01	5.94	36.06	1.78
July	10.25	19.80	9.08	62.10	8.13	28.36	4.03
August	13.78	47.65	6.26	106.47	8.47	44.06	5.16
September	9.17	110.00	4.48	122.78	16.07	35.14	3.26
Average	10.99	44.23	8.60	96.36	13.57	35.58	4.71
IN SECOND FOOT.							
April	18.14	24.45	10.75	25.10	27.64	20.52	9.92
May	17.07	7.54	3.82	21.80	10.05	7.34	5.87
June	13.64	1.54	8.25	35.50	9.89	13.90	1.71
July	16.69	6.66	7.32	42.20	5.79	13.46	3.91
August	15.55	4.93	4.84	40.80	7.91	8.47	1.35
September	16.05	14.80	3.23	35.30	10.14	6.73	3.11
Average	16.19	9.99	6.37	33.45	11.90	11.74	4.31
IN THIRD FOOT.							
April	21.07	30.84	10.18	19.68	24.58	23.05	11.42
May	20.31	9.98	3.10	12.18	8.10	11.13	6.33
June	20.05	7.04	9.27	24.94	10.56	15.78	3.64
July	15.07	6.24	6.38	11.25	3.57	13.31	3.08
August	19.98	7.58	4.18	21.19	6.75	8.69	3.35
September	19.05	14.10	1.66	15.23	11.90	6.05	5.20
Average	19.26	12.63	5.80	17.41	10.91	13.00	5.50

Amount of water-soluble salts in soil under potatoes on Selma silt loam, Goldsboro, N. C.—1902—Continued.

IN FOURTH FOOT.

Month.	Soil moisture.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_3.
	Per cent.						
April	21.73	27.90	9.38	12.59	28.52	30.99	11.08
May	17.74	11.73	2.44	2.31	6.61	11.93	6.46
June	17.10	8.80	9.02	12.71	8.81	11.93	1.96
July	16.01	4.86	6.06	11.40	2.90	11.78	2.52
August	18.93	6.73	3.98	15.37	6.69	9.55	3.37
September	16.28	12.70	0.81	6.84	8.69	5.05	4.67
Average	17.93	12.12	5.28	10.20	10.37	13.54	5.01

Amounts of water-soluble salts in soil under cotton on Norfolk sandy soil, Goldsboro, N. C.—1902.

[Salts in parts per million of dry soil.]

IN SURFACE FOOT.

Month.	Soil moisture.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_3.
	Per cent.						
April	10.13	28.70	18.20	94.09	....	....	1.46
May	9.06	50.00	10.56	57.78	9.08	13.59	1.99
June	6.95	37.85	9.86	54.72	7.87	20.64	2.48
July	3.41	2.99	10.21	26.78	16.38	13.17	1.86
August	5.26	2.54	0.72	8.11	10.30	8.22	0.35
September	3.74	1.30	2.88	96.00	7.62	4.42	2.39
Average	6.43	20.56	8.73	56.25	10.25	12.01	1.76

IN SECOND FOOT.

Month.	Soil moisture.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_3.
April	16.42	3.01	11.30	35.38	....	....	5.46
May	13.01	9.03	4.28	50.11	10.18	12.23	5.08
June	11.39	4.18	7.33	40.00	6.24	9.64	8.54
July	7.29	1.74	8.82	37.85	11.87	7.29	3.56
August	8.46	3.22	1.94	8.43	6.69	6.99	0.30
September	8.93	0.98	2.24	40.00	4.01	5.44	2.53
Average	10.92	3.69	5.99	35.30	7.80	8.32	4.25

IN THIRD FOOT.

Month.	Soil moisture.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_3.
April	16.28	22.70	9.70	3.42	....	....	7.01
May	15.75	8.07	3.61	6.75	11.84	11.77	6.98
June	13.85	6.51	6.70	10.52	6.22	11.17	5.15
July	11.73	7.66	6.94	6.52	6.91	11.73	5.21
August	10.99	4.60	0.77	10.80	4.12	8.77	0.74
September	12.61	4.88	1.55	4.93	6.96	4.85	4.50
Average	13.54	9.07	4.88	7.16	7.21	9.66	4.93

IN FOURTH FOOT.

Month.	Soil moisture.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_3.
April	19.19	38.40	9.30	3.57	....	....	11.22
May	16.55	14.93	3.23	1.71	7.40	14.35	7.71
June	15.61	10.72	4.82	3.46	8.57	10.42	6.40
July	14.95	12.88	5.98	5.62	7.14	26.60	7.11
August	14.16	12.30	0.79	13.32	5.64	12.28	0.38
September	14.81	14.76	2.39	1.12	9.28	8.74	6.53
Average	15.88	17.33	4.42	4.80	7.61	14.48	6.56

Amounts of water-soluble salts in soil under cotton on Goldsboro compact sandy loam, Goldsboro, N. C.—1902.

[Salts in parts per million of dry soil.]

IN SURFACE FOOT.

Month	Soil moisture.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_3.
	Per cent.						
April	11.24	5.08	19.21	32.40	29.56	38.95	4.46
May	9.45	10.82	5.74	48.71	2.92	20.62	2.17
June	10.23	13.89	8.85	36.24	5.86	34.11	1.33
July	8.67	4.29	6.51	35.91	9.93	26.34	1.79
August	9.29	4.00	2.24	11.60	6.69	29.72	0.00
September	7.76	3.18	2.21	43.60	13.21	32.60	2.48
Average	9.44	6.88	7.13	34.74	11.36	28.72	2.04

IN SECOND FOOT.

Month	Soil moisture.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_3.
April	12.49	3.91	9.34	23.80	26.78	22.65	6.92
May	11.98	4.08	4.12	14.90	4.61	8.31	3.48
June	12.75	2.85	6.49	12.35	5.57	9.22	2.70
July	10.88	2.15	6.29	21.45	8.21	18.71	1.48
August	11.25	6.22	1.53	6.48	5.49	5.58	0.37
September	9.89	2.44	1.51	20.30	9.48	4.72	2.55
Average	11.54	3.61	4.88	16.55	10.02	11.53	2.92

IN THIRD FOOT.

Month	Soil moisture.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_3.
April	15.61	4.22	8.02	20.95	22.51	18.16	8.14
May	14.08	4.40	3.14	10.37	6.84	8.76	3.94
June	14.34	2.83	6.06	13.92	4.76	9.31	2.67
July	13.77	1.60	5.92	20.54	5.66	11.52	1.34
August	13.51	3.39	1.57	6.66	4.23	6.55	0.38
September	12.49	2.44	1.55	9.86	11.13	3.23	0.25
Average	13.97	3.15	4.38	13.72	9.19	9.59	2.79

IN FOURTH FOOT.

Month	Soil moisture.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_3.
April	19.84	5.85	23.30	17.15	23.12	16.75	9.26
May	15.88	5.08	2.40	1.13	3.36	7.81	4.13
June	16.37	4.29	4.83	10.80	5.30	10.07	3.11
July	14.62	2.58	6.17	10.38	5.36	12.45	1.63
August	15.47	4.18	0.80	5.62	5.71	5.82	0.39
September	13.64	3.29	0.79	2.77	7.05	4.09	2.65
Average	15.97	4.21	6.38	7.98	8.32	9.50	3.53

AVERAGE RESULTS FOR THE SEASON.

The averages of these three soil types for each foot in depth, and their sums, are given in the following table:

Mean amounts of salts recovered from three soil types during the season of 1902, Goldsboro, N. C.

[Salts in parts per million of dry soil.]

Soil and depth.	Moisture.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_3.	Total.
Selma silt loam:	*Per cent.*							
Surface foot	10.99	44.23	8.60	99.36	13.57	35.58	4.71	206.05
Second foot	16.19	9.99	6.37	33.45	11.90	11.74	4.31	77.76
Third foot	19.26	12.63	5.80	17.41	10.91	13.00	5.50	65.25
Fourth foot	17.93	12.12	5.28	10.20	10.37	13.54	5.01	56.52
Sums [a]	....	78.97	26.05	160.42	46.75	73.86	19.53	405.58
Norfolk sandy soil:								
Surface foot	6.43	20.56	8.73	56.25	10.25	12.01	1.76	109.56
Second foot	10.92	3.69	5.99	35.30	7.80	8.32	4.25	65.35
Third foot	13.54	9.07	4.88	7.16	7.21	9.66	4.93	42.91
Fourth foot	15.88	17.33	4.42	4.80	7.61	14.48	6.56	55.20
Sums [a]	....	50.65	24.02	103.51	32.87	44.47	17.50	273.02
Goldsboro compact sandy loam:								
Surface foot	9.44	6.88	7.13	34.74	11.36	28.72	2.04	90.87
Second foot	11.54	3.61	4.88	16.55	10.02	11.53	2.92	49.51
Third foot	13.97	3.15	4.38	13.72	9.19	9.59	2.79	42.82
Fourth foot	15.97	4.21	6.38	7.98	8.32	9.50	3.53	39.92
Sums [a]	....	17.85	22.77	72.99	38.89	59.34	11.28	223.12

[a] These are the sums of the "parts per million" in the first, second, third, and fourth feet, and represent parts per 4 million of dry soil.

The dry weights of these three soils per cubic foot, as determined in April, are as given in the following table:

Dry weights of soil per cubic foot of the three soil types—1902.

Soils.	First foot.	Second foot.	Third foot.	Fourth foot.	Average.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Selma silt loam	90.02	101.10	104.30	106.50	100.50
Norfolk sandy soil	94.45	95.72	103.00	107.00	100.04
Goldsboro compact sandy loam	97.00	106.00	106.80	106.60	104.10

These are remarkably heavy soils, at all depths, exceeding 4 million pounds per acre-foot in all cases except the surface foot of the Selma silt loam, which is itself nearly 4 million pounds per acre, 91.8 pounds per cubic foot equalling this value.

It will be near enough, for comparative results here, to compute the total water-soluble salts recovered by the three-minute washing from the surface 4 feet of soil in these 3 types, by using the "sums" and the mean weights per cubic foot of the surface 4 feet of soil given in the last two tables. On this basis we obtain the following comparative values:

Amounts of water-soluble salts recovered from the surface 4 feet of three soils—1902.

[In pounds per acre.]

Soils.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_3.	Total.
Selma silt loam	346	114	689	205	323	86	1,763
Norfolk sandy soil	201	105	451	143	194	76	1,170
Goldsboro compact sandy loam	91	103	331	176	269	51	1,021

From these results it is seen that relatively large amounts of salts are either actually in solution in the soil moisture of these fields, or they are in such soluble form that they at once enter solution when that moisture is diluted with distilled water. Only the acid radicals measured are included in the sums under consideration; but later investigations have shown that not less than 55 per cent more must be added to include the bases—potash, lime and magnesia—which have been found present in similarly recoverable forms. If, therefore, we increase the above amounts 55 per cent we shall have in the surface 4 feet the totals shown in the following table:

Total amounts of water-soluble salts in the three soils—1902.

[In pounds per acre.]

Soils.	Acid radicals.	Bases.	Total salts.
Selma silt loam	1,763	970	2,733
Norfolk sandy soil	1,170	644	1,814
Goldsboro compact sandy loam	1,021	562	1,583

The relative amounts of total salts recovered from the three soils on the basis of 100 for the largest amount are as follows:

Selma silt loam	100.00
Norfolk sandy soil	66.37
Goldsboro compact sandy loam	57.92

Water-Soluble Salts Recovered from Twenty Cotton Fields on each of Three Soil Types.

On July 21, 1902, the field party was divided into three sections and each, with a team, collected soil samples and plant samples from 20 different cotton fields on each of the 3 soil types—Selma silt loam, Norfolk sandy soil, and Goldsboro compact sandy loam—as mapped by the Bureau.

The distance covered by each party was from 15 to 25 miles, the localities for collecting having been previously designated upon the soil maps. The fields were sampled between the rows in this series to avoid as far as practicable the influence of fertilizers recently applied to the soils. The sampling was done to a depth of 4 feet and 1 core was taken from each field, care being exercised to select typical average conditions for the places of sampling. The 20 cores from each depth were put together, thus constituting 20-core composites in every case.

A typical and average plant was also chosen from each locality, and these plants were worked into composite samples and examined for water-soluble salts in the sap of the plants. The dry weights of the plants were determined to serve as a basis for comparative yields on the 3 soil types. It should be observed that the fields visited for

these composite samples represent on the average farms not so well cared for as those lying near the city, where both mineral fertilizers and stable manure are more extensively and generally used.

In the table which follows are given the results obtained from this series of observations:

Water-soluble salts in the surface 4 feet of three soil types taken under cotton July 21 from 20 different localities, and in cotton plants growing thereon—1902.

[Salts in parts per million of dry weight.]

Soil types.	Moisture.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_3.	Total.
IN SURFACE FOOT.								
	Per cent.							
Selma silt loam	3.58	12.12	8.96	13.70	4.01	15.54	2.16	56.49
Norfolk sandy soil	4.17	6.48	5.67	14.00	5.08	8.84	1.37	41.44
Goldsboro compact sandy loam	8.34	11.13	7.05	12.60	4.01	10.87	.54	46.20
IN SECOND FOOT.								
Selma silt loam	14.03	5.34	9.10	11.10	4.23	18.02	3.99	51.78
Norfolk sandy soil	8.81	4.40	6.70	6.32	4.02	14.00	2.52	37.96
Goldsboro compact sandy loam	10.38	6.12	5.30	9.06	2.73	15.85	2.57	41.63
IN THIRD FOOT.								
Selma silt loam	16.28	5.28	8.90	6.84	2.89	20.19	6.62	50.72
Norfolk sandy soil	11.73	3.63	5.40	8.70	4.14	14.43	5.95	42.25
Goldsboro compact sandy loam	13.13	4.11	5.50	5.55	2.82	16.38	4.91	39.27
IN FOURTH FOOT.								
Selma silt loam	16.96	4.79	8.55	6.31	2.19	22.86	6.07	50.77
Norfolk sandy soil	12.74	9.04	5.44	12.09	1.40	22.70	5.64	56.31
Goldsboro compact sandy loam	15.07	4.58	4.79	4.50	4.29	14.98	5.77	38.91
IN COTTON PLANTS.								
Selma silt loam	338.70	412	3,425	10,380	2,759	12,652	2,788	32,416
Norfolk sandy soil	340.50	1,799	3,355	10,674	3,003	16,903	2,674	38,409
Goldsboro compact sandy loam	300.00	529	2,567	8,991	2,821	15,451	2,803	33,160

The total salts recovered from the surface 4 feet in the three cases are given in the following table:

Amount of water-soluble salts recovered from the surface 4 feet of soils of the three types—1902.

[In parts per million of dry soil.]

Depth.	Selma silt loam.	Norfolk sandy soil.	Goldsboro compact sandy loam.
Surface foot	56.49	41.44	46.20
Second foot	51.78	37.96	41.63
Third foot	50.72	42.25	39.27
Fourth foot	50.77	56.31	38.91
Sums [a]	209.76	177.96	166.01

[a] Parts per 4 million.

Water-Soluble Salts Recovered from Thirteen "Fallow" Fields on Two Soil Types.

Immediately after the last series of samples was taken, two other sets were collected from fields of Selma silt loam and Goldsboro compact sandy loam, which had for some time been allowed to run to weedy fallow. These 13 fields were immediately adjacent to fields of the other series and samples were collected here to secure results from soils less influenced by fertilization. The results obtained appear in the next table:

Mean water-soluble salts recovered from 13 fields for some time under weedy fallow and not recently fertilized—1902.

[Salts in parts per million of dry soil.]

Soil and depth.	Moisture.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_3.	Total.
Selma silt loam:	*Per cent.*							
Surface foot	6.83	1.87	9.51	3.61	23.26	9.15	0.71	48.11
Second foot	12.87	1.21	9.76	4.95	16.79	13.01	5.08	50.80
Third foot	16.01	1.84	10.50	3.42	15.93	16.82	6.61	55.12
Fourth foot	16.69	1.38	9.77	2.30	16.22	16.90	8.21	54.78
Sums [a]		6.30	39.54	14.28	72.20	55.88	20.61	208.81
Goldsboro compact sandy loam:								
Surface foot	3.64	1.11	4.93	4.48	8.84	8.80	.68	28.84
Second foot	7.29	2.60	4.77	7.28	9.25	13.78	3.72	41.40
Third foot	9.77	3.06	5.30	3.20	6.78	9.45	5.46	33.25
Fourth foot	12.74	3.06	5.45	2.20	6.29	11.36	6.39	34.75
Sums [a]		9.83	20.45	17.16	31.16	43.39	16.25	138.24

[a] Parts per 4 million.

If the totals for the 4 feet of each of the ingredients are compared for each of the three series the results stand as below:

Amounts of different water-soluble salts found in three series of investigations—1902.

[In parts per 4 million of dry soil, being sums of the parts per million in the 1st, 2d, 3d, and 4th feet.]

Soils from—	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_3.	Total.
Selma silt loam:							
Single field, best care	78.95	26.05	157.42	46.75	73.86	19.53	402.56
20 fields, less care	27.53	35.51	37.95	13.32	76.61	18.84	209.76
13 fields, weedy fallow	6.30	39.54	14.28	72.20	55.88	20.61	208.81
Goldsboro compact sandy loam:							
Single field, best care	17.85	22.77	72.99	38.89	59.34	11.28	223.12
20 fields, less care	25.94	22.64	31.71	13.85	58.08	10.79	163.01
13 fields, weedy fallow	9.83	20.45	17.16	31.16	43.39	16.25	138.24
Wooded tract (see p. 45)	17.54	23.23	10.39	47.10	49.10	15.74	163.10

It will be seen from this table that the weedy fallow fields are only lower in NO_3, SO_4, and Cl than those covered by the 20-core composites, as probably would be anticipated from the withholding of fertilizers; and it is worthy of note that they are higher in phosphates and bicarbonates in the Selma silt loam type.

Water-Soluble Salts Recovered from a Wooded Tract.

There was a wooded tract bearing old trees on the area mapped as Goldsboro compact sandy loam near the laboratory, upon which salt

determinations were made on five dates from April to August for the purpose of comparison with cultivated-field conditions. The data obtained are those given in the next table:

Water-soluble salts in wooded tract of large trees on Goldsboro compact sandy loam—1902.

[Salts in parts per million of dry soil.]

Date.	Moisture.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_3.
FIRST FOOT.							
	Per cent.						
April 22	19.05	17.40	11.60	14.07	13.76	19.45	4.00
May 1	18.77	4.88	4.99	1.17	9.31	15.04	3.99
May 13	13.76	1.13	5.50	1.11	31.74	4.18	3.79
May 23	11.23	.80	4.60	1.09	4.11	5.56	.37
August 4	8.46	.98	5.96	2.63	10.70	9.32	.72
Average	....	5.04	6.53	4.01	13.92	10.71	2.57
SECOND FOOT.							
April 22	14.29	15.20	11.00	6.70	9.55	16.54	3.82
May 1	15.61	4.48	2.38	1.13	17.85	13.80	8.51
May 13	14.03	.51	4.75	1.12	10.61	16.46	4.95
May 23	12.37	.91	3.88	1.10	7.70	5.63	2.27
August 4	10.99	1.80	6.89	2.16	8.24	11.16	2.22
Average	....	4.58	5.78	2.44	10.79	12.72	4.35
THIRD FOOT.							
April 22	17.70	17.20	11.50	5.75	17.25	19.83	2.36
May 1	18.62	4.56	3.32	1.17	12.93	17.22	6.38
May 13	17.65	1.82	4.91	1.16	11.00	8.52	5.53
May 23	15.87	.74	2.41	1.15	3.58	7.53	4.27
August 4	14.16	1.54	7.08	1.16	7.05	6.55	1.91
Average	....	5.17	5.84	2.08	10.36	11.93	4.09
FOURTH FOOT.							
April 22	18.06	7.10	9.80	4.64	12.87	17.50	3.96
May 1	20.48	4.18	3.37	1.19	12.03	13.15	6.89
May 13	19.78	1.10	4.18	1.18	10.86	21.00	6.04
May 23	19.47	.65	1.66	1.17	18.68	10.41	5.23
August 4	14.68	.73	6.38	1.13	5.71	6.66	1.53
Average	....	2.75	5.08	1.86	12.03	13.74	4.73
Mean sums [a] of 4 feet	....	17.54	23.23	10.39	47.10	49.10	15.74

[a] Parts per 4 million of dry soil.

When these results are compared with the other data from this same soil type it will be seen that there is a fair agreement, they being nearest to those of the weedy fallow and containing less sulphates and chlorides and more phosphates, bicarbonates, and silica than the fertilized field.

The 3 types of soil thus far considered are the ones which were in close proximity to the laboratory, and during the season a large number of observations were made upon them, especially at places where there were evident differences in crop condition. The determinations made are all assembled in the following table, irrespective

of fertilizations which the soils had received up to the time of collecting, or of the conditions of crop growing upon them, in order to secure a general average of the salt content recovered from them by the method of treatment:

Amounts of water-soluble salts recovered from the surface 4 feet of three soil types—average of all determinations—1902.

[In parts per 4 million of dry soil, being sums of the parts per million in the 1st, 2d, 3d, and 4th feet.]

Soil type.	Number of determinations.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_3.
Selma silt loam	128	39.77	29.41	74.33	38.53	58.53	27.33
Norfolk sandy loam	64	22.33	24.53	106.28	43.77	45.83	21.77
Goldsboro compact sandy loam	144	51.16	31.99	121.77	45.58	67.99	24.89
Average for the three types	....	37.75	28.64	100.79	42.63	57.45	24.66
Pounds per acre	....	166.1	126.1	443.5	187.6	252.8	108.5

The mean weight per cubic foot of the surface 4 feet for each of these 3 soils is almost identical, and very close to 100 pounds, or 4,408,707 pounds per acre-foot. The values in the last line of the above table are computed from the round number, 4,400,000.

The relation of lime, magnesia, and potash to the negative radicals here considered for the surface 4 feet in 2 of the soil types and in 2 others closely allied to them, as shown by an average of 28 determinations, are given below:

Relation of lime, magnesia, and potash to the negative radicals determined in the surface 4 feet of four soil types—1903.

[In parts per 4 million of dry soil, being sums of the parts per million in the 1st, 2d, 3d, and 4th feet.]

Salts.	Norfolk sandy soil.	Selma silt loam.	Norfolk sand.	Sassafras sandy loam.
Potash, lime, and magnesia	183.79	202.70	183.24	195.41
Negative radicals determined	425.84	284.95	229.39	408.08

As a mean, for these 4 soils, the 3 bases recovered are, in round numbers, about 57 per cent of the negative radicals. Using this percentage, we may roughly compute the total soluble salts recovered from these soils by the method used:

	Pounds.
Total observed negative radicals	1,284.8
Total computed lime, magnesia, and potash	732.1
Total	2,016.9

It would appear, therefore, to be a safe conclusion that the 3 soil types in question carry in their surface 4 feet something more than a ton of salts per acre, either dissolved in their soil moisture or in a form so readily soluble that it may be brought into solution very quickly by increasing the amount of water.

Water-Soluble Salts in Three Other Soil Types.

There were 3 other soil types in the vicinity of Goldsboro, which were examined in the spring and again in the fall by the method used; these were the Sandhill, Norfolk fine sandy loam, and Pocoson.

The Sandhill soil is described by W. G. Smith of the Bureau, as "a gray, sharp, incoherent sand of considerable depth—from 10 to 50 feet or more—found usually in the form of high, flat ridges or hills. The first 6 or 9 inches are generally bleached, while the underlying portion is of a brown-reddish color and of the same texture as the soil."

The Norfolk fine sandy loam "consists of a mellow, fine, sandy loam, from 10 to 15 inches deep, overlying a yellow, rather stiff clay subsoil."

The Pocoson type "possesses a character distinctly incident to location. Generally speaking, it is a swampy area, depressed from 2 to 10 feet below the surface of the surrounding land. The typical Pocoson consists of a black, spongy, mucky soil supporting a scattering growth of scrub pine, a dense undergrowth of gallberry shrubs, wire grass, and broom sedge."

In the table which follows are given the data obtained from the two sets of determinations:

Water-soluble salts recovered from the surface 4 feet of three soil types—1902.

[Salts in parts per 4 million of dry soil—sums of the parts per million in the 1st, 2d, 3d, and 4th feet.]

Time of sampling.	Dry soil, weight per cubic foot.	Moisture.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_3.
SAND HILL, VIRGIN CONDITION.								
	Pounds.	*Per cent.*						
May 29	....	2.67	3.43	6.98	0.00	30.10	25.99	3.71
September 2	....	2.70	15.92	10.44	0.00	27.46	36.26	2.71
Average	99.19	2.69	9.68	8.71	0.00	28.78	31.13	3.21
SAND HILL, UNDER POTATOES, FERTILIZED.								
May 29	....	9.75	16.78	14.22	66.84	25.40	50.28	9.70
September 3	....	6.49	17.25	17.59	23.44	27.46	34.27	7.43
Average	110.28	8.12	17.02	15.91	45.14	26.43	42.28	8.57
NORFOLK FINE SANDY LOAM, UNDER POTATOES AND COTTON.								
May 30	....	12.59	160.70	27.32	84.71	25.28	141.96	5.19
August 26	....	11.92	88.82	17.78	79.44	30.27	77.19	11.08
Average	100.09	12.26	124.76	22.55	82.08	27.78	109.58	8.14
POCOSON, UNDER CORN.								
May 30	....	18.23	65.34	36.94	13.96	27.05	46.40	16.22
August 27	....	20.65	11.21	14.20	54.30	26.94	29.88	20.69
Average	87.84	19.44	38.28	25.57	34.13	27.00	38.14	18.46

From this table it will be seen that the application of fertilizers to the sand-hill type of soil very materially increased the amounts of salts recovered from this soil, and also that at the end of the season the sulphates and chlorides had materially decreased. So, too, in the other 2 types of soil there was a notable decrease at the time of the last sampling, as was to be expected from the manner of applying the fertilizers under the rows.

Attention is called to these changes to indicate the difficulty in comparing soil types as to the amounts of water-soluble salts which may be recovered from them.

Expressing the total salts recovered from the surface 4 feet of these soil types, as was done for the last group, we have the following:

Total water-soluble salts recovered from surface 4 feet of three soil types, respectively—1902.

[In parts per 4 million of dry soil, being sums of the parts per million in the 1st, 2d, 3d, and 4th feet.]

Salts.	Virgin sand hill.	Fertilized sand hill.	Norfolk fine sandy loam.	Pocoson.
Total observed negative radicals	81.51	155.85	374.99	181.81
Total computed lime, magnesia, and potash	46.46	88.83	213.74	113.63
Total	127.97	244.68	588.73	295.44
Total pounds per acre, for 4 feet	552.9	1,175.5	2,587.0	1,131.50

COMPARISON OF SOIL TYPES—RECONNOISSANCE SERIES.

After the studies at Goldsboro had progressed to the first of August and the field methods had become well advanced, it seemed best in the judgment of the Chief of the Bureau, to change the plan of the season's work and make a reconnoissance study covering a considerable number of soil types which had been mapped, and which were widely separated by distance, physical characters, and climatic environment.

Collection of Samples.

There were many difficulties in the way of making a satisfactory investigation of such a character under the conditions which existed at the time and place where the work must be done, the greatest of which was the getting of the samples from the field to the laboratory. A supply of small, thin-walled, rubber ice bags was procured, carefully washed, dried, and one was placed in each of the small cloth soil sacks used by the Bureau in sending samples by mail. Under these conditions myself and an assistant collected the series of soils reported in the next table.

The samples were collected with the soil tube, 4 cores constituting a composite sample for each of the first 4 feet. The cores were transferred, as taken in the field, directly from the soil tube to the rubber

ice bag, the neck of which was tied and then the cloth sack, with its mailing tag, was secured over it. In this condition the samples were mailed directly to the laboratory at Goldsboro, where the determinations were made as they were received.

By this arrangement a contamination of the samples was avoided and they reached the laboratory with the moisture content but little changed from that which existed when the collection was made. Nothing, however, could be done to prevent either nitrification, or the reverse taking place during transit, which usually required from two to four days. There is little reason to think that denitrification occurred to any measurable extent, and whatever of nitrification did occur was influenced by the same time element for all samples collected on the same day; some sets of samples, however, were longer exposed to the altered conditions than others, but the greatest difference in time did not exceed one week.

Results of Determinations of Water-Soluble Salts.

It is not thought best for this series to take the space required for giving separate results for each foot determined, and the table which follows is made out, giving the sums of the determinations on the 4 feet for each soil examined:

Water-soluble salts recovered from different soils, collected in several States during August and September, 1902.

[In parts per 4 million of dry soil, being sums of the parts per million in the 1st, 2d, 3d, and 4th feet.]

State and locality, soil and crop.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_3.
Georgia, Covington district:						
Cecil clay, cotton	32.83	17.24	17.90	36.76	72.28	52.68
Cecil sandy loam, cotton	47.85	21.72	23.05	31.71	42.00	38.95
Maryland, Prince George County:						
Collington sandy loam, corn	3.17	5.53	4.36	32.32	26.05	22.35
Elkton clay, corn	5.21	3.88	15.45	39.01	28.47	23.17
Leonardtown loam, corn	6.08	7.36	11.16	57.14	29.39	33.21
Norfolk loam, corn	6.91	2.44	17.23	29.04	20.44	42.51
Norfolk sand, corn	10.45	7.09	11.45	26.89	20.54	12.97
Sassafras loam, corn	7.04	4.50	18.83	35.45	16.64	24.91
Susquehanna clay, corn	3.82	9.75	5.61	36.77	23.83	40.57
Susquehanna clay loam, corn	5.80	6.37	22.24	23.59	15.82	22.65
Westphalia sand, corn	6.03	4.01	16.26	47.89	24.71	30.09
Windsor sand, corn	5.96	8.91	27.68	82.80	18.03	6.86
North Carolina, Goldsboro district:						
Goldsboro compact sandy loam, cotton	11.35	6.06	76.53	40.87	44.64	9.93
Norfolk sandy soil, cotton	21.92	9.01	142.05	27.87	26.31	15.95
Norfolk fine sandy loam, cowpeas	88.92	17.78	79.44	30.27	77.19	11.08
Pocoson, corn	13.21	14.20	54.50	26.49	29.88	20.69
Sandhill, virgin wood	15.92	5.56	0.00	27.46	36.26	3.04
Sandhill, potatoes	17.25	10.37	25.54	16.37	34.27	10.84
Sandhill, cotton	16.16	19.47	68.88	24.89	33.31	15.06
Selma heavy silt loam, cotton	22.76	29.41	16.85	24.72	25.61	16.10
Selma silt loam, potatoes	151.60	10.18	180.15	46.77	53.97	16.24
North Carolina, Graham district:						
Cecil clay, wheat	39.75	30.16	24.65	53.81	96.02	30.93
Iredell clay loam, corn	26.87	32.41	14.05	43.61	72.35	73.80
North Carolina, Edgecombe test farm:						
Plat 27, fertilized, corn	12.49	17.85	148.12	46.99	34.71	23.17
Plat 14, fertilized, corn	12.46	30.76	95.55	90.87	47.86	32.97
Plat 14, not fertilized, corn	15.14	22.65	60.19	82.07	44.70	34.29
Cotton after cowpeas	15.47	28.76	17.99	51.17	26.82	30.20
Cotton after peanuts	8.68	34.83	40.63	109.40	39.20	29.85

Water-soluble salts recovered from different soils, collected in several States during August and September, 1902—Continued.

State and locality, soil and crop.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_3.
North Carolina, Hickory district:						
Cecil clay, cotton	28.78	28.84	19.14	29.06	37.46	29.56
Cecil clay, virgin wood	4.59	22.12	10.02	29.68	54.02	24.96
Iredell clay loam, good corn	12.16	13.11	10.78	21.02	47.62	25.97
Iredell clay loam, poor corn	8.01	13.37	11.15	27.25	39.83	53.93
New Jersey, Trenton district:						
Alloway clay, corn	10.21	3.48	124.82	58.33	23.76	95.69
Collington sandy loam, corn	15.81	7.46	34.28	34.32	15.63	21.05
Elsinboro fine sand, corn	7.59	15.63	12.76	29.35	26.13	6.77
Sassafras loam, corn	11.68	11.38	59.35	25.03	19.63	23.84
Pennsylvania, Lancaster district:						
Cecil mica loam, corn	16.55	19.63	60.16	11.03	6.95	11.60
Conestoga loam, corn	31.90	4.95	31.24	94.75	13.84	37.34
Conestoga loam, tobacco	56.82	3.28	46.26	35.64	18.46	32.89
Conestoga loam, grain seeded to timothy and clover	26.98	1.64	48.55	77.85	14.66	30.91
Hagerstown clay loam, corn	28.13	10.12	51.28	12.69	25.25	25.34
Hagerstown clay, corn	30.85	14.35	61.30	35.73	25.55	47.25
Hagerstown clay, timothy and clover	33.25	8.99	32.32	21.21	19.48	39.67
Hagerstown loam, corn	64.55	7.50	78.28	19.58	17.58	28.48
South Carolina, Abbeville district:						
Cecil clay, cotton	74.06	35.14	18.54	52.46	124.29	32.13
Cecil sandy loam, cotton	38.94	10.95	18.76	43.34	39.98	33.96
Davie clay loam, cotton	43.90	23.06	41.52	31.37	69.85	39.48
Durham sandy loam, cotton	23.60	10.97	7.73	52.33	32.21	21.33
Iredell clay loam, cotton	42.50	29.81	14.24	89.48	56.79	212.40
Wisconsin, Janesville district:						
Edgerton silt loam, timothy	8.08	3.32	32.54	120.90	10.16	128.34
Hanover silt loam, corn	90.91	9.90	61.05	37.19	35.49	67.86
Hanover silt loam, timothy	13.09	8.45	63.83	25.75	47.64	77.05
Janesville loam, corn	334.32	12.65	48.55	30.46	26.55	65.22
Janesville loam, timothy	14.44	9.44	76.41	27.67	27.84	78.10
Miami loam, corn	68.88	13.41	55.69	12.01	19.26	19.09
Miami loam, timothy and blue grass	7.64	9.86	43.09	26.97	18.85	33.00
Wisconsin, university farm, Madison:						
Under rape	13.04	13.11	55.71	27.60	22.73	74.70
Under fallow ground	83.48	11.81	92.72	76.13	24.51	78.26
Under lawn	5.89	18.07	76.74	147.18	8.83	106.61
Under corn	6.34	39.56	87.29	135.54	3.78	119.73
Virginia, Elkton district:						
Hagerstown clay, fall plowed	24.89	13.54	40.85	44.10	38.17	105.31
Hagerstown shale loam, fall plowed	66.34	21.44	10.56	13.70	19.94	48.57
Hagerstown shale loam, corn	40.70	35.87	9.05	7.29	21.46	35.85
Virginia, Roanoke district:						
Hagerstown clay, corn	22.12	4.89	42.18	29.31	23.85	57.67
Hagerstown clay, clover	9.74	5.09	17.21	5.28	28.04	55.74

Though samples of soil were collected from eight States, not all of the data obtained as a result of this reconnoissance are included in the table, as there were a number of soils examined of which it was not practicable to obtain samples from all of the 4 feet, and these have not been included in the table.

It is the writer's judgment that the relatively high salt content for the soils of Georgia and South Carolina are to a considerable extent due to a protracted drought which had prevailed in the regions where the samples were taken and which, through capillary rise and long and strong evaporation, had concentrated the salts in the zone sampled. Indeed, these soils were so dry and hard in some places that it was impossible to take samples. The rainfall conditions of Wisconsin and Maryland had not been very different from each other, but it is quite possible that the New Jersey soils had been reduced in salt content somewhat by rains, and perhaps also those of the Pennsylvania area.

In figure 3 are represented graphically the variations of the mean amounts of phosphates with the depths as averages by States. The heavy lines on the right side represent the parts per million of dry soil, and those on the left side the pounds per acre-foot. It will be observed that there is a tendency for the amounts to decrease with the depth when expressed as parts per million of the dry soil, and this is

CHART SHOWING PHOSPHATES RECOVERED FROM SOILS IN EIGHT STATES.

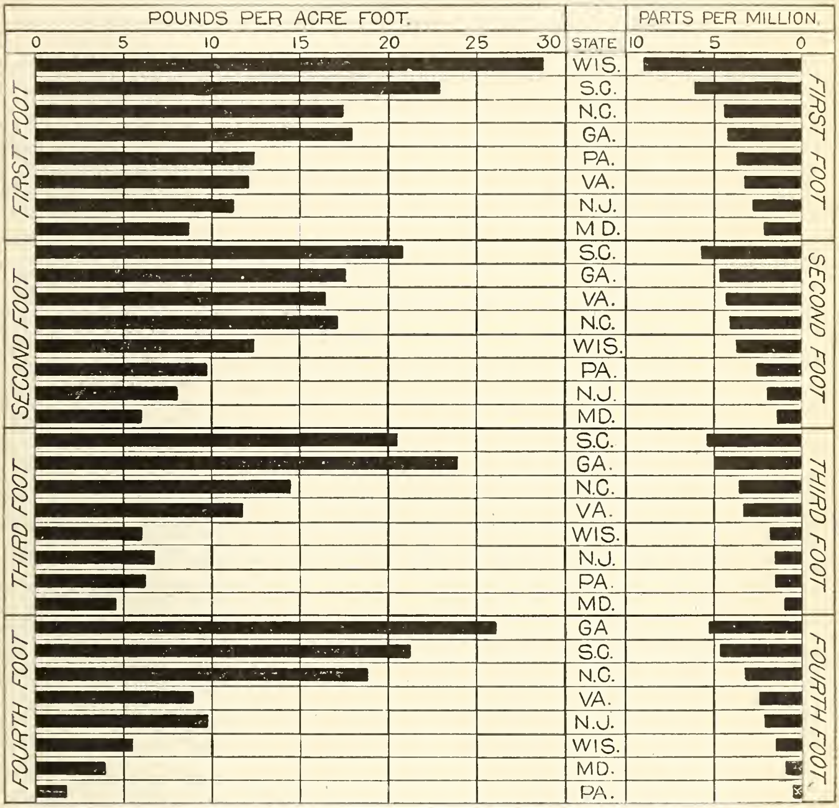


FIG. 3.—Chart showing relative amounts of phosphates recovered from soils of eight States by washing once with distilled water. Pounds per acre-foot on left, parts per million on right.

marked enough not to be wholly reversed by the heavier weight of the soil as the depth increases. With the Georgia samples, however, the reverse relation holds quite strongly, but here only two types have been studied. The decrease with depth is most marked in the Wisconsin and Pennsylvania soils. It is worthy of remark in this connection that Hilgard's analyses of soils and subsoils (Tenth Census reports) shows the same tendency for both the light and heavy types.

When the data obtained from all samples are combined into averages for the respective States, regardless of soil types, the results are as follows:

Mean amounts of water-soluble salts recovered from the surface 4 feet of soils grouped by States—1902.

[In parts per 4 million of dry soil, being sums of the parts per million in the 1st, 2d, 3d, and 4th feet.]

State.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_3.	Total.
Georgia	40.34	19.50	20.48	34.24	57.14	45.83	217.53
Maryland	5.97	5.73	14.75	41.69	22.51	25.43	116.08
North Carolina	31.74	15.35	53.45	28.69	41.36	19.50	190.09
New Jersey	12.80	8.78	47.38	39.67	24.46	37.79	170.88
Pennsylvania	35.28	8.19	57.22	42.57	17.98	29.29	190.53
South Carolina	44.60	21.98	20.15	53.77	64.26	67.85	272.61
Virginia	26.12	13.54	23.86	21.10	27.96	49.84	162.42
Wisconsin	56.65	15.58	62.39	59.95	21.43	77.41	293.41
General average for sum of 4 feet	31.69	13.58	37.46	40.21	34.64	44.12	201.69
General average per foot of depth[a]	7.92	3.40	9.37	10.05	8.66	11.03	50.41

[a] Parts per million.

If the values in this table and those in the general table (pp. 49 and 50) are multiplied by 4 the results will approximately represent pounds per acre for the surface 4 feet of soil, except the last line of averages, where the results will be pounds per acre-foot.

It will be seen that in the arbitrary grouping of the data by States, there are with some groups, notably those of Wisconsin and Maryland, well-marked differences between the amounts of nearly every ingredient determined, the ratio for the totals being 2.53 to 1. It should be understood that no value in the table of averages is derived from less than eight determinations and none in the general table from less than four. The Maryland averages are derived from 40 determinations and the Wisconsin from more than 44.

If the soils of this reconnoissance series are classified on the physical basis adopted by the Soil Survey into 3 broad groups, four of the salts determined by the methods will stand as given in the next table:

Mean amounts of water-soluble salts recovered from soils of 3 groups classified on a physical basis—1902.

[Salts in parts per 4 million of dry soil, being sums of the parts per million in the first, second, third, and fourth feet.]

Group of soils.	Number of determinations.	NO_3.	HPO_4.	SO_4.	SiO_3.
Sands, fine sands, sandy loams	81	14.68	11.44	27.72	14.32
Fine sandy loams, loams, shale loams, silt loams	101	56.17	15.68	53.77	35.71
Clay loams, clays	85	25.01	16.46	27.77	55.89

If the salts recovered from the first group of soils are taken as 1, the amounts recovered from the other two groups stand relatively as follows:

Relative amounts of water-soluble salts recovered from soils of the 3 groups, assuming the amounts for the first group to be 1—1902.

Group of soils.	Number of determinations.	NO_3.	HPO_4.	SO_4.	SiO_3.
Sands, fine sands, sandy loams	81	1	1	1	1
Fine sandy loams, loams, shale loams, silt loams	101	3.83	1.37	1.94	2.49
Clay loams and clays	85	1.74	1.44	1	3.91

The silica and phosphoric acid increase with the fineness of texture of the soil, but the nitrates and sulphates have been obtained in largest amounts from the intermediate groups.

When the same data are grouped and averaged on the basis of size of the soil grains, as indicated by the rate of flow of air through pestled samples, there appears to be no relation of amounts of water-soluble salts to the size of soil grains, unless possibly the phosphates recovered do increase as the size of the soil grains decreases. The observed mean amounts of water-soluble salts recovered from these soils, grouped on the basis of the size of the soil grains, as indicated by the observed rates of flow of air through the pestled soils, are given in the next table:

Mean amounts of water-soluble salts recovered from soils grouped on the basis of the mean effective sizes of the soil grains—1902.

[Salts in parts per million of dry soil.]

Time for flow of 1 cubic foot of air.	Number of samples.	NO_3.	HPO_4.	SO_4.	SiO_3.
Seconds.					
50 to 10,000	33	9.52	2.16	14.09	5.72
10,000 to 20,000	30	6.87	2.67	11.94	8.77
20,000 to 30,000	35	16.64	3.04	12.03	15.60
30,000 to 40,000	37	8.05	2.52	12.48	10.63
40,000 to 50,000	31	4.21	2.61	7.29	7.01
50,000 to 100,000	58	7.95	3.16	8.39	8.25
100,000 to 200,000	15	7.30	2.89	7.08	14.18
200,000 to 500,000	10	5.30	6.47	1.62	11.28

To measure the degree of fineness of the grains of soils composing this series, air-dry portions were rubbed down lightly in the mortar with a pestle and the rate of flow of air through them was measured by the aspirator method.[a] From the observed rates the times required for a cubic foot of air to flow through a cubic foot of soil under a pressure of 10 cm. of water and at a temperature of about 70° F. have been computed and the soils classified on this basis.

It is clear from the table that there is no evident relation of amounts of salts recovered to the sizes of the grains and granules resulting from pestling, and therefore to differences in the amounts of soil surface exposed to the solvent. It is well known that the loamy character of

[a] Principles and Conditions of Movement of Ground Water, XIX Annual Report, U. S. Geological Survey, Part II, page 222.

a soil is determined much more by the nature and extent of the granulation than by the size of the grains which compose the granules; and the two classifications of the data here made may be regarded as indicating that a larger readily recoverable water-soluble salt content is associated with the highly granular loamy soils, either as a cause or an effect. It is well recognized, also, that, on the average, the loamy types are the most productive soils.

Gravimetric Determinations of the Total Salts Recovered.

In view of the fact that one of the prime objects of the season's work of 1902 was to develop and check field methods and to ascertain if comparative results for total salts could be secured by the electrical method, it was concluded to determine the total salts in the solutions recovered from the surface foot of 67 samples of this series of soils by the gravimetric method.

To obtain a sufficient quantity of solution for this work four 100-gram lots of soil were washed in the usual manner in 500 cc. of distilled water, and the four solutions made into a composite from which 1 liter was taken for the gravimetric determinations and 50-cc. lots of the same composite for the colorimetric work.

In the gravimetric work weighings were made after drying at 110° C., on a chemical Springer torsion balance. Unfortunately, the particular instrument sent by the firm direct to the field laboratory proved not to be as sensitive as was expected, and readings beyond milligrams could not be depended upon.

The results obtained from the 67 surface-foot determinations are given in the next table:

Mean total solids recovered from 67 surface-foot samples of soil, washing 3 minutes with distilled water in the ratio of about 5 of water to 1 of soil and drying at 110° C.—1902.

State.	Number of determinations.	Mean dry weight of soil per cubic foot.	Total solids.	[a]Relative amounts.	Total solids.
		Pounds.	*Parts per million.*		*Pounds per acre-foot.*
Georgia	2	91.33	328.8	69.50	1,308
Maryland	11	85.41	263.6	55.72	981
New Jersey	6	81.57	297.6	61.90	1,057
North Carolina	19	88.23	315.7	66.73	1,216
Pennsylvania	9	75.76	402.6	85.10	1,673
South Carolina	5	85.35	337.4	71.32	1,255
Virginia	9	80.14	224.3	47.41	783
Wisconsin	6	75.28	473.1	100.00	1,953
General average	67	82.88	330.4	....	1,278

[a] The numbers in this column show the relative size of the totals appearing in the preceding column, assuming that 100 represents the largest, that of Wisconsin.

From this table there are seen to be very measurable differences between the groups of soils from the different States in the amounts of solids which were recovered from them using distilled water; the

Wisconsin soils yielding more than two times the amount recovered from the Virginia samples.

The largest amount of solids recovered from the surface-foot of any soil was 934.7 parts per million in the case of a Janesville loam and the smallest amount, omitting three doubtful results, came from the Selma heavy silt loam, 140.9 parts per million of the dry soil. The first, or largest amount, represents well up toward 2 tons of soluble matter per acre-foot, or 0.3 per cent of the soil moisture, computed on a saturation equal to one-third the dry weight of the soil.

COMPARATIVE RESULTS OF WORK WITH FRESH AND OVEN-DRIED SAMPLES.

In developing field methods for the lines of investigation in soil management it was realized that, if it were admissible to examine the samples after they had been rendered water-free, this would not only greatly simplify the calculation of the results but the samples could be oven-dried at once as taken from the field and then transported without material change, and even kept for some time before the determinations were made.

Amount of Water-Soluble Salts Recovered from Water-Free Soils Dried at 110° C.

At several times during the season of 1902 comparisons were made of the amounts of salts which could be recovered (1) from the fresh samples; (2) from the same samples quickly air-dried in the sun; (3) from the same immediately oven-dried at 110° C. and treated at once. In the following tables are given the results of an examination of eight sets of soil samples, in each case covering the surface 4 feet, examined fresh from the field and again direct from the dry oven.

Amounts of NO_3 recovered from fresh and oven-dried samples of the same soils—1902.

[In parts per million of dry soil.]

Soil.	First foot.		Second foot.		Third foot.		Fourth foot.	
	Dry.	Wet.	Dry.	Wet.	Dry.	Wet.	Dry.	Wet.
Norfolk sandy soil	6.45	6.48	5.10	4.40	6.02	3.63	9.27	9.04
Selma silt loam	10.75	12.12	9.47	5.34	6.99	5.28	8.68	4.79
Goldsboro compact sandy loam	8.81	11.13	8.00	6.12	7.40	4.11	6.71	4.58
Collington sandy loam	3.89	1.98	3.85	.53	5.03	.33	1.37	.33
Leonardtown loam	9.38	2.20	6.77	2.61	3.37	.71	1.78	.56
Windsor sand	6.50	2.31	2.85	.53	3.03	.58	5.48	2.54
Westphalia sand	3.52	4.01	4.59	1.02	4.91	.42	2.26	.58
Goldsboro compact sandy loam	3.53	1.68	4.32	1.00	3.53	2.13	5.29	2.88
Average	6.60	5.24	5.62	2.69	5.04	2.15	5.11	3.16
Mean excess from dry	1.36	....	2.91	....	2.89	....	1.94	....
Mean per cent of excess	26.05	....	108.59	....	134.32	....	61.42	....

From this table it will be observed that, on the average, more nitrates were recovered from the oven-dried samples, 26.05 per cent more (computed on the amount from the wet soil) having been recovered from the surface foot, 108.59 per cent more from the second

foot, 134.32 per cent more from the third, and 61.42 per cent more from the fourth foot. If the comparison is made on the combined results of the 32 determinations the oven-dried samples have yielded 68.85 per cent more NO_3 than the fresh field samples did. It should be observed that all exceptions to the oven-dried samples yielding the larger amounts of NO_3 occur in the surface foot where, in numbers, the cases are equally divided.

The next table shows the relations observed in the case of the phosphates for the same series of 32 samples:

Amounts of HPO_4 recovered from fresh and oven-dried samples of the same soils—1902.

[In parts per million of dry soil.]

Soil.	First foot.		Second foot.		Third foot.		Fourth foot.	
	Dry.	Wet.	Dry.	Wet.	Dry.	Wet.	Dry.	Wet.
Norfolk sandy soil	13.39	5.67	10.30	6.72	10.96	5.40	9.52	5.46
Selma silt loam	14.69	8.96	11.57	9.10	11.80	8.90	10.29	8.55
Goldsboro compact sandy loam	16.12	7.05	11.20	5.30	11.10	5.50	11.67	4.79
Collington sandy loam	1.49	2.27	1.55	1.60	1.60	.83	1.61	.83
Leonardtown loam	4.90	3.37	3.24	1.66	2.38	1.55	.76	.88
Windsor sand	2.92	3.68	2.18	2.21	1.45	1.47	1.52	1.55
Westphalia sand	2.37	1.62	.76	.78	.78	.80	.00	.81
Goldsboro compact sandy loam	4.40	2.27	1.35	.38	1.35	.78	.67	.00
Average	7.53	4.36	5.27	3.47	5.18	3.15	4.51	2.86
Mean excess from dry	3.17	....	1.80	....	2.03	....	1.65	....
Mean per cent of excess	72.77	....	51.89	....	64.17	....	57.58	....

With the phosphates it will be observed that in rather more than two-thirds of the cases the oven-dried samples have yielded the larger amounts of HPO_4, the exceptions being distributed quite regardless of depth. From the different depths there were recovered from the oven-dried samples 72.77 per cent more from the first, 51.89 more from the second, 64.17 more from the third, and 57.58 per cent more from the fourth foot, making a general average of 62.44 per cent more. This was a very great surprise, as we had anticipated that the reverse relation would be found to occur.

The relative amounts of sulphates recovered in the two sets of determinations appear in the next table.

Amounts of SO_4 recovered from fresh and oven-dried samples of the same soils—1902.

[In parts per million of dry soil.]

Soil.	First foot.		Second foot.		Third foot.		Fourth foot.	
	Dry.	Wet.	Dry.	Wet.	Dry.	Wet.	Dry.	Wet.
Norfolk sandy soil	39.72	14.00	41.50	6.32	10.65	8.70	7.53	12.09
Selma silt loam	62.11	13.70	52.18	11.10	39.91	6.84	12.82	6.31
Goldsboro compact sandy loam	64.03	12.60	42.09	9.06	28.03	5.55	16.45	4.50
Collington sandy loam	78.59	2.67	14.73	1.69	27.69	0.00	7.39	0.00
Leonardtown loam	69.03	7.72	3.42	2.34	1.61	1.10	1.07	0.00
Windsor sand	20.10	9.36	7.68	2.60	16.36	3.12	23.10	12.60
Westphalia sand	89.22	6.27	25.78	5.48	37.48	3.37	6.66	1.14
Goldsboro compact sandy loam	76.32	70.39	35.30	15.70	31.01	21.90	14.29	13.32
Average	62.39	17.09	27.84	6.78	24.19	6.32	11.16	6.24
Mean excess from dry	45.30	....	21.06	....	17.87	....	4.92	....
Mean per cent of excess	265.09	....	310.17	....	281.06	....	78.76	....

Here again we met with a surprise for there is but one exception in the 32 pairs to more SO_4 being recovered from the oven-dried samples, and the difference is very large, sulphates being found in three cases where no reaction occurred in the solution from the fresh samples. As a general average 2.44 times as much SO_4 was recovered from the oven-dried samples. It will be observed that enormous differences have occurred in the surface foot of three of the Maryland samples, while in one of the samples of the Goldsboro compact sandy loam only a small difference was found. Differences like these can only come from some conditions associated with the drying of the samples which result in a larger amount of SO_4 coming from the oven-dried samples.

The results obtained in the recovery of bicarbonates from the same samples before and after drying in the oven appear in the next table:

Amounts of HCO_3 recovered from fresh and oven-dried samples of the same soils—1902.

[In parts per million of dry soil.]

Soil.	First foot.		Second foot.		Third foot.		Fourth foot.	
	Dry.	Wet.	Dry.	Wet.	Dry.	Wet.	Dry.	Wet.
Norfolk sandy soil	9.47	5.08	9.22	4.02	8.11	4.14	8.19	1.40
Selma silt loam	5.26	4.01	2.76	4.23	2.82	2.89	4.25	2.19
Goldsboro compact sandy loam	19.68	4.01	5.34	2.73	2.74	2.82	8.36	4.29
Collington sandy loam	21.96	8.13	24.94	8.57	21.54	7.44	20.25	8.18
Leonardtown loam	19.00	18.11	24.62	17.86	21.75	10.43	18.31	9.74
Windsor sand	24.22	19.80	27.31	23.70	35.06	20.20	31.37	19.10
Westphalia sand	34.00	13.03	20.45	10.43	14.70	12.85	11.99	11.58
Goldsboro compact sandy loam	16.96	14.90	19.40	18.80	13.32	12.52	10.90	11.98
Average	18.82	10.88	16.76	11.29	15.01	9.16	14.20	8.56
Mean excess from dry	7.94		5.46		5.84		5.65	
Mean per cent of excess	72.97		48.37		63.78		65.95	

In this series of observations there are but three exceptions in 32 pairs to the recovery of more HCO_3 from the oven-dried samples. The mean of the determinations for first foot shows 72.97 per cent more, for the second foot 48.37 per cent more, for the third foot 63.78 per cent more, and for the fourth foot 65.95 per cent more, while the general mean represents a difference of 62.38 per cent more from the oven-dried samples.

In the case of the chlorides, the results of determinations for which are given in the next table, on the whole, greater amounts were obtained from the wet samples:

Amounts of Cl recovered from fresh and oven-dried samples of the same soils—1902.

[In parts per million of dry soil.]

Soil.	First foot.		Second foot.		Third foot.		Fourth foot.	
	Dry.	Wet.	Dry.	Wet.	Dry.	Wet.	Dry.	Wet.
Norfolk Sandy soil	7.33	8.84	12.24	14.00	17.30	14.43	22.21	22.70
Selma silt loam	7.64	15.54	8.02	18.02	9.82	20.19	6.58	22.86
Goldsboro compact sandy loam	13.72	10.87	7.76	15.85	14.33	16.38	16.19	14.98
Collington sandy loam	3.86	4.72	6.43	7.49	9.18	6.92	5.87	6.92
Leonardtown loam	6.79	7.01	10.10	8.64	6.31	8.08	6.30	5.66
Windsor sand	3.80	4.60	13.22	4.60	6.03	3.84	7.92	4.99
Westphalia sand	2.47	5.05	5.54	7.27	7.34	6.50	6.54	5.89
Goldsboro compact sandy loam	40.81	49.00	5.63	4.78	4.22	4.85	4.22	4.09
Average	10.80	13.20	8.62	10.08	9.32	10.15	9.48	11.01
Mean excess from wet		2.40		1.46		.83		1.53
Mean per cent of excess		18.19		20.72		8.20		13.92

In the first-foot samples there is but one exception to more chlorine being recovered from the fresh samples; there are 2 in the second-foot, 4 in the third-foot, and 5 in the fourth-foot samples. There appear, therefore, to be conditions which on the whole tend to give less Cl from the surface-foot samples after being oven-dried and quite possibly also for all samples.

When the results obtained for the SiO_3 are brought into tabular form they stand as recorded below.

Amounts of SiO_3 recovered from fresh and oven-dried samples of the same soils—1902.

[In parts per million of dry soil.]

Soil.	First foot.		Second foot.		Third foot.		Fourth foot.	
	Dry.	Wet.	Dry.	Wet.	Dry.	Wet.	Dry.	Wet.
Norfolk sandy soil	7.80	1.37	18.43	2.52	26.02	5.95	16.89	5.64
Selma silt loam	13.79	2.16	22.65	3.99	23.11	6.62	24.00	6.07
Goldsboro compact sandy loam	17.65	.54	20.13	2.57	27.82	4.91	13.11	5.77
Collington sandy loam	18.61	1.82	23.88	5.74	40.19	7.57	39.65	7.22
Leonardtown loam	17.29	3.65	35.85	11.26	20.84	7.47	20.09	10.83
Windsor sand	4.23	1.07	8.39	1.78	10.47	1.77	19.08	2.24
Westphalia sand	16.38	3.13	22.40	6.77	34.27	10.83	24.27	9.36
Goldsboro compact sandy loam	6.84	1.83	11.73	4.06	13.36	3.01	14.33	3.81
Average	12.82	1.95	20.43	4.84	24.51	7.27	21.43	6.37
Mean excess from dry	10.87	....	15.59	....	17.24	....	15.06	....
Mean per cent of excess	588.89	....	322.49	....	237.31	....	236.51	....

It will be seen from these data that, as was the case with the SO_4, in every case more SiO_3 was recovered from the oven-dried samples, another result which was not anticipated. Indeed, so great has been the change brought about by the drying that the means of the 32 pairs of determinations stand in the following ratio: Oven-dried to wet as 19.80 to 5.10; and the excess recovered from the oven-dried samples is nearly 3 times the total recovered from the fresh field samples. The amounts obtained for the different depths show the following ratios in favor of the oven-dried samples: In the surface foot, 6.58 to 1; in the second foot, 4.22 to 1; in the third foot, 3.37 to 1; in the fourth foot, 3.35 to 1.

There is thus seen to be a progressive decrease as the depth increases. If the ratios of all of the ingredients are brought into one table they stand as given below:

Ratios of ingredients recovered from the oven-dried and fresh field samples, the first term in each ratio representing the result with the oven-dried samples—1902.

	First foot.	Second foot.	Third foot.	Fourth foot.
NO_3	1.26:1.00	2.09:1.00	2.34:1.00	1.61:1.00
HPO_4	1.73:1.00	1.52:1.00	1.64:1.00	1.58:1.00
SO_4	3.66:1.00	4.10:1.00	3.81:1.00	1.79:1.00
HCO_3	1.73:1.00	1.48:1.00	1.64:1.00	1.66:1.00
Cl	.82:1.00	.83:1.00	.92:1.00	.86:1.00
SiO_3	6.58:1.00	4.22:1.00	3.37:1.00	3.35:1.00

CAUSES OF THE DIFFERENCES IN RESULTS WITH FRESH AND OVEN-DRIED SAMPLES.

It was established by observations made at the time that the differences in the amounts of the ingredients recovered from the two series of determinations above cited were not due to products of combustion absorbed by the samples of soil during the drying. A blue-flame kerosene stove was used as a source of heat for drying the soil samples in question, and the products of combustion passed up through the dry oven. We also had in the laboratory another dry oven heated with gasoline. At the time one of the above sets of determinations was being made an aspirator was arranged so as to draw, very slowly, through 100 cc of distilled water between 10 and 15 liters of air directly from each of the two ovens. Both of these solutions gave very slight but measurable amounts of NO_3, but the test for SO_4, HPO_4, and SiO_3 showed that on adding the reagents the solutions remained so clear that they were indistinguishable from distilled water.

The smaller amounts of chlorine recovered from the oven-dried samples, so far as they are not due to variations in the samples and in the determinations, may, perhaps, be explained on the basis of Voelcker's[a] observations in connection with his studies on the absorption of soda by soils, wherein he explains an apparent absorption of chlorine by the soil on the basis of its loss in the form of ammonium chloride by evaporation. It must, however, be recognized that, in the cases in hand, only temperatures of 110° C. affected the soils during their drying. The apparent greater loss of chlorine and of NO_3 from the surface foot happens to occur where most ammonia in the samples would be expected to have existed, but it may be quite as probable that these losses of chlorine should be attributed to irregularities in samples or in determinations.

The increased amounts of salts recovered from the dried soils must, I think, be admitted to indicate the presence in them of larger quantities, in readily water-soluble form, than are likely to be recovered by washing the fresh moist samples in five times their weights of distilled water. Why so much more was recovered of all ingredients determined, except chlorine, is not altogether clear.

That the soil moisture at the temperature of 100° C. and somewhat above, for its last remnants, should increase the solubility of some of the salts is perhaps to be expected, especially if sulphates, phosphates, and silicates are locked up with the organic matter of the soil. So long as much moisture remains in the soil a partial cooking of the organic matter would result, which, if it causes disintegration of the organic matter, may be expected to liberate soluble materials which could hardly be recovered by the rapid, brief washing; and if these

[a] Journal Royal Agricultural Society, second series, vol. 1, p. 289.

remain soluble after having been brought to a water-free condition, larger amounts would be recovered from the oven-dried samples.

With what is known of the "fixing" power of solid surfaces for materials carried in solutions about them, and the known higher concentration of solutions near solid surfaces, together with the comparatively slow rate at which diffusion of salts can take place away from solid surfaces about which a concentration has taken place, it is to be expected that when a mass of dry soil grains and granules, with their surfaces dusted over with the residues of evaporation, are thrown at once into distilled water and vigorously agitated a much higher per cent of the easily and quickly soluble material will at once reach the body of water than could, in the same time, diffuse into the solvent from the films held by the soil grains and carried with them through the water during the short period of agitation which has been adopted for this work.

Moreover, if the fixing power of soils for substances held in solution is to a considerable extent physical, it may be that the water itself plays an important part in this retention of salts; if so, rendering the sample water-free may be expected to permit rapid solution at first, and if the water with the salts to be dissolved is taken away from the absorbing surfaces before opportunity for absorption has occurred a larger amount of salts would be recovered from the water-free soil than from the moist sample.

Then, again, on account of the granular nature of soils there is reason to expect that a large per cent of readily soluble salts is carried in the moisture imbibed by the granules themselves, and that during the process of drying considerable amounts of these salts are brought out upon the surfaces and deposited where they may more readily find their way into solution during the brief period of treatment and thus cause the oven-dried samples to yield larger amounts of salts with the same treatment than moist soils do, provided, of course, the salts remain soluble to a large extent after having been thrown out of solution by drying in this way.

In one case a liter of soil extract was evaporated to dryness in a porcelain evaporating dish, taking care to drive off the last portion of the water by placing the dish in the dry oven at a temperature of 110° C. The residue when taken up again in a liter of water gave all of the ingredients previously determined in the original solution as closely as duplication is possible with the methods.

There is no question but that oven-dried samples do yield solutions carrying much more dissolved organic matter; and solutions from soils so prepared are always more or less highly colored, sometimes so much so as to resemble a manure extract.

The later investigations which were made preparatory to the season's work of 1903 relative to the amounts of potash, lime, and magnesia

recovered from oven-dried samples of soils and of plants as well, as compared with those moist and fresh, showed that of these much larger amounts were recovered from the samples in oven-dried condition.

Having worked one season with fresh samples, having demonstrated that larger amounts of all ingredients, unless it be chlorine, could be obtained from the oven-dried materials, and on account of the simplification of work and saving of time in the laboratory and in calculating results, it was deemed best to conduct the work of 1903 on the basis of dry rather than of fresh samples, and we feel that the results have gained rather than lost in value from the change.

If it be urged that by making the change we have obtained more salts than can be held to have been in solution in the soil moisture at the time the samples were collected, it may be answered that even if this be true the results are still comparable and comparative, and they show differences between different soil and crop conditions, the demonstration of which has been the prime object of the studies. Moreover, it must be conceded that whatever salts have been recovered from soils in the work on oven-dried samples have been in eminently available form, so far as solubility is concerned.

EXAMINATION OF EIGHT SOIL TYPES IN FOUR STATES.

With a colorimetric method for the determination of potash, brought out by Doctor Cameron, and with methods for similarly determining lime and magnesia, devised by Doctor Schreiner and Mr. Ferris, of this Bureau, during the winter and spring of 1903, plans were perfected for following the soluble salt content of eight soil types through the season with a view to testing the availability of such methods for investigations in soil management, and for ascertaining if measurable differences in the water-soluble content of different soil types do exist, and if these may be correlated with differences in the management of the soils and with the yields from them.

Description of Soil Types.

The soils chosen were two at Goldsboro, N. C., the Norfolk sandy soil, and Selma silt loam, described on page 36; two at Upper Marlboro, Md., the Norfolk sand and Sassafras sandy loam; two at Lancaster, Pa., the Hagerstown clay loam and Hagerstown loam; and two at Janesville, Wis., the Janesville loam and Miami loam.

The Norfolk sand is described (Field Operations of the Bureau of Soils, 1901, p. 188) as consisting of a medium to coarse orange yellow sand having a depth of about 10 inches. It is underlain by coarse sandy subsoil which usually becomes loamy at a depth of about 3 feet.

The Sassafras sandy loam consists of a brown sandy loam of medium to fine-grained texture. It has an average depth of about 10 inches. The soil proper is underlain by a slightly sandy or rather heavy yellow loam, usually more than 5 feet in depth.

The Hagerstown clay loam (Field Operations of Bureau of Soils, 1900, p. 80), usually consists of about 10 to 12 inches of dull reddish-brown clay loam underlain by a stiff clay loam of the same color. At 24 inches a red clay, similar to that under the Hagerstown loam, is found, and this continues to a depth of several feet.

The Hagerstown loam is described in the same report (p. 68) as follows: The soils are yellowish-brown mellow loams, containing a fair proportion of clay. They are from 8 to 12 inches deep and contain a goodly share of organic matter derived from liberal applications of manure, which they receive at least every four or five years. * * * The subsoils contain less organic matter and a greater proportion of clay, and may be classed as clay loams. * * * At an average depth of 24 inches the yellow-clay loam grades into a stiff red clay.

The Janesville loam (Field Operations, 1902, p. 554) consists of a surface soil of fine brown loam from 12 to 14 inches in depth. It is underlain to a depth of several feet by a fine, massive, yellow loam of very uniform texture. It is neither markedly clayey nor sandy.

The Miami loam (same report, p. 557) for the surface 8 inches, consists of a compact brown loam containing from 15 to 30 per cent of coarse, rounded quartz sand. This sand content varies through moderate limits over single fields. From 8 inches to an average depth of about 18 inches the subsoil consists of a sticky, reddish sandy loam, frequently spoken of locally as "sandy clay." This is uniformly underlain by a deeper subsoil of fine to medium gravel embedded in a sticky matrix of sand and clay.

Type mechanical analyses of these soils (except the two previously given) are included in the next table, as recorded in the respective reports referred to above:

Mechanical analyses of six soils made from type samples collected by the soil survey.

Soil.	Sample number.	Organic matter and loss.	Gravel, 2–1mm.	Coarse sand, 1–0.5 mm.	Medium sand, 0.5–0.25 mm.	Fine sand, 0.25–0.1 mm.	Very fine sand, 0.1–0.05 mm.	Silt, 0.05–0.005 mm.	Clay, 0.005–0.0001 mm.
Norfolk sand:		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Surface soil	5485	1.90	2.10	11.78	24.54	32.12	7.16	13.32	5.79
Subsoil	5486	1.90	Trace.	8.98	22.56	31.50	6.42	15.72	12.03
Sassafras sandy loam:									
Surface soil	5497	3.10	....	....	2.76	14.30	13.42	43.90	24.27
Subsoil	5498	4.32	....	....	1.60	13.66	4.88	48.74	26.61
Hagerstown clay loam:									
Surface soil	4966	5.67	1.81	1.72	1.15	2.41	5.95	65.69	16.06
Subsoil	4967	6.04	2.84	1.96	2.50	4.98	8.98	47.79	24.44
Hagerstown loam:									
Surface soil	4952	4.63	2.02	3.28	3.25	6.50	11.92	54.28	14.17
Subsoil	4953	3.19	1.29	1.75	1.84	4.13	10.58	49.57	27.66
Janesville loam:									
Surface soil	7088	5.78	.10	.48	.40	.90	6.19	72.86	18.38
Subsoil	7089	1.49	Trace.	.30	.30	.94	6.84	75.60	15.92
Miami loam:									
Surface soil	7094	3.12	1.54	12.48	15.70	10.58	3.88	38.34	17.10
Subsoil	7095	.89	4.50	22.76	24.20	13.80	2.60	20.20	11.52

The mean effective diameters of the surface foot of the specific soils worked with, as indicated by the aspirator method, are given in the next table, where the samples have been treated in the condition of the field texture and also after having been pestled one, two, three, and four times.

Mean effective diameters of soil grains of the surface foot of the eight soils sampled for the work of 1903.

Soil.	Field texture.	Pestled once.	Pestled twice.	Pestled three times.	Pestled four times.
	mm.	*mm.*	*mm.*	*mm.*	*mm.*
Norfolk sandy soil	0.06531	0.01807	0.01754	0.01694	0.01563
Selma silt loam	.04808	.02168	.01850	.01334	.01208
Norfolk sand	.06753	.04418	.03365	.02831	.02612
Sassafras sandy loam	.03445	.02460	.02030	.01707	.01360
Hagerstown clay loam	.03386	.01500	.01401	.00870	.00586
Hagerstown loam	.03910	.01409	.01092	.00994	.00947
Janesville loam	.03638	.01353	.01172	.00957	.00944
Miami loan	.05018	.02163	.01589	.01365	.01235

From these results it is seen that, in the condition of the field texture, the Norfolk sand was the coarsest soil and the Hagerstown clay loam the finest. After having been four times pestled the same order still holds for these two types; but in the Norfolk sand the diameters have been reduced to only a little more than one-third, while in the other case they have been reduced nearly to one-sixth what they were under the field texture.

Amounts of Water-Soluble Salts Recovered from the Surface Four Feet.

On three dates during the season the 8 soils under consideration were examined for water-soluble salts in each of the surface 4 feet, samples being taken as described on pages 27 and 109. The collected data are given as the means of the sums of the surface 4 feet for each of the 3 dates, as averages for the 3 dates for the 4 feet, and computed to pounds per acre for each ingredient determined.

Amounts of water-soluble salts in the surface 4 feet of eight soil types recovered in distilled water by a single washing during three minutes—1903.

[Salts in parts per 4 million of dry soil, being sums of the parts per million in the 1st, 2d, 3d, and 4th feet; and in pounds per acre.]

Date of sampling.	Dry soil per cubic foot.	Moisture.		K.	Ca.	Mg.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_2.
		Per cent.	Inches.									
NORFOLK SANDY SOIL.												
	Lbs.											
April 29	102.99	20.03	4.12	52.91	100.65	63.44	25.18	45.72	207.90	89.60	16.00	66.96
June 24	97.86	16.01	3.06	44.09	95.60	40.90	49.66	32.68	178.60	46.00	14.00	109.39
August 24	103.16	15.10	3.04	45.55	78.50	29.74	35.18	17.50	174.25	75.00	10.00	83.90
Average	101.34	17.05	3.41	47.52	91.58	44.69	36.67	31.97	186.92	70.20	13.33	86.75
Pounds per acre				209.75	404.23	197.26	161.86	141.12	825.06	309.86	58.84	382.91
SELMA SILT LOAM.												
April 29	79.59	24.40	3.75	46.35	146.95	47.33	10.70	29.64	219.70	−9.60	23.20	76.79
June 24	83.93	22.29	3.63	37.39	115.86	40.89	49.20	55.46	247.90	0.00	9.00	72.44
August 24	85.47	23.09	3.87	44.44	81.88	47.00	20.38	14.90	179.75	62.00	17.00	76.40
Average	83.00	23.26	3.75	42.73	114.90	45.07	26.76	33.33	215.78	17.47	16.40	75.21
Pounds per acre				154.47	415.36	162.93	96.74	120.49	780.04	63.15	59.29	271.88

Amounts of water-soluble salts in the surface 4 feet of eight soil types recovered in distilled water by a single washing during three minutes—1903—Continued.

Date of sampling.	Dry soil per cubic foot.	Moisture. Per cent.	Moisture. Inches.	K.	Ca.	Mg.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_2.
NORFOLK SAND.												
	Lbs.											
April 29	92.17	15.14	2.83	50.35	115.24	40.42	12.18	90.46	109.00	6.40	16.40	11.77
June 24	95.34	17.29	3.17	36.85	80.00	37.58	37.08	36.40	162.00	86.40	8.00	44.65
August 24	94.50	12.66	2.22	52.18	88.38	48.71	58.54	13.55	180.50	17.00	1.00	96.85
Average	94.00	15.03	2.74	46.46	94.54	42.24	35.93	46.80	150.50	36.60	8.47	51.09
Pounds per acre	......	......	......	190.21	387.05	172.93	147.10	191.60	616.15	149.84	34.68	209.16
SASSAFRAS SANDY LOAM.												
April 29	84.56	21.53	3.53	50.93	109.40	58.08	21.40	59.90	238.70	4.60	16.00	30.00
June 24	84.23	21.05	3.42	52.90	116.46	42.36	46.91	33.21	350.60	43.20	12.40	39.07
August 24	87.38	16.63	2.80	37.45	76.63	42.04	34.69	16.30	158.75	19.00	6.00	95.65
Average	85.39	19.74	3.25	47.09	100.83	47.49	34.33	36.47	249.35	22.27	11.47	54.91
Pounds per acre	......	......	......	175.13	374.99	176.62	127.67	135.63	927.33	82.82	42.66	204.21
HAGERSTOWN CLAY LOAM.												
April 29	87.94	25.14	4.24	37.65	191.38	77.10	39.67	62.86	370.10	140.00	18.00	105.09
June 24	89.50	25.58	4.39	43.27	141.20	70.63	94.77	49.65	274.10	88.00	3.00	63.05
August 24	92.47	23.38	4.13	65.84	460.65	86.37	66.03	56.45	450.25	......	......	73.60
Average	89.97	24.70	4.25	48.92	264.41	78.03	66.82	56.32	364.82	114.00	10.50	80.58
Pounds per acre	......	......	......	191.72	1,036.22	305.80	261.87	220.72	1,429.73	459.19	42.29	324.58
HAGERSTOWN LOAM.												
April 29	88.32	23.22	3.97	60.06	140.75	65.06	41.95	64.44	239.60	69.00	18.00	88.38
June 24	91.65	25.35	4.46	47.67	152.25	62.37	176.49	29.44	183.20	85.00	9.00	110.48
August 24	93.48	22.74	4.11	73.54	377.25	79.92	97.48	50.50	521.25	......	......	86.30
Average	91.15	23.77	4.18	60.42	223.42	69.12	105.31	48.13	314.63	77.00	13.50	95.05
Pounds per acre	......	......	......	246.03	909.77	281.46	428.82	195.99	1,281.38	313.54	54.97	387.04
JANESVILLE LOAM.												
April 29	83.98	24.18	3.84	109.41	335.35	135.00	118.80	153.80	774.60	102.00	9.00	195.60
June 24	82.06	23.35	3.64	72.40	189.95	73.73	209.68	80.04	448.20	38.00	2.40	225.08
August 24	83.71	22.67	3.58	118.05	355.50	136.93	132.46	43.65	738.00	......	......	198.90
Average	83.25	23.40	3.69	99.95	293.60	115.22	153.65	92.16	653.60	70.00	5.70	206.53
Pounds per acre	......	......	......	364.42	1,070.47	420.09	560.21	336.02	2,383.03	255.22	20.78	753.01
MIAMI LOAM.												
April 29	82.01	18.13	2.81	85.82	297.10	139.26	29.53	111.56	719.10	131.00	13.00	111.11
June 24	87.57	14.78	2.46	67.45	289.65	91.95	93.64	50.56	464.00	55.40	2.00	157.74
August 24	86.75	16.99	2.82	50.66	246.25	75.17	35.31	66.17	465.00	......	......	88.20
Average	85.44	16.63	2.70	67.98	277.67	102.13	52.83	76.10	549.37	93.20	7.50	119.02
Pounds per acre	......	......	......	256.90	1,049.31	385.95	199.64	287.58	2,076.07	352.20	28.34	449.78

In this table each value, for the first two dates, is the average of the sums for the 4 feet for 20 determinations, and for the last date of 8 determinations. There are, therefore, 48 determinations entering the values in the lines of averages, and each determination was made

upon a composite sample of 4 soil cores. The 8 soil types have, therefore, been very thoroughly and systematically sampled over an area of 2 acres in each case.

It will be seen from this table that the potash, as K, recovered from the 8 soil types ranges from 154 to 364 pounds per acre in the surface 4 feet computed upon the observed dry weights of the respective soils; the lime, as Ca, ranges from 375 pounds per acre in the Sassafras sandy loam to 1,070 pounds in the Janesville loam; the magnesia, as Mg, ranges from 163 pounds per acre to 420 pounds; the nitrogen, as NO_3, from 97 pounds to 560 pounds per acre; and the phosphoric acid, as HPO_4, from 120 pounds per acre to 336 pounds. When it is stated that these are the amounts of salts recovered from the zone actually occupied by agricultural crops when soils are in the best physical condition, and that they were obtained with water alone during but a brief period of contact, it is clear not only that large amounts of soluble salts exist in soils within the immediate reach of crops, but that, whether expressed as absolute amounts or as percentages, considerable differences do occur even in humid climates.

The total salts in each soil type recovered from the 4 feet are given in the next table:

Total salts recovered from the surface 4 feet of eight soil types—1903.

[In pounds per acre.]

Salts.	Norfolk sandy soil.	Selma silt loam.	Norfolk sand.	Sassafras sandy loam.	Hagerstown clay loam.	Hagerstown loam.	Janesville loam.	Miami loam.
K	209.75	154.47	190.21	175.13	191.72	246.03	364.42	256.90
Ca	404.23	415.36	387.05	374.99	1,036.22	909.77	1,070.47	1,049.31
Mg	197.26	162.93	172.93	176.62	305.80	281.46	420.09	385.95
NO_3	161.86	96.74	147.10	127.67	261.87	428.82	560.21	199.64
HPO_4	141.12	120.49	191.60	135.63	220.72	195.99	336.02	287.58
SO_4	825.06	730.04	616.15	927.33	1,429.73	1,281.38	2,383.03	2,076.07
HCO_3	309.86	63.15	149.84	82.82	459.19	313.54	255.22	352.20
Cl	58.84	59.29	34.68	42.66	42.29	54.97	20.78	28.34
SiO_3	382.91	271.88	209.16	204.21	324.58	387.04	753.01	449.78
Total	2,690.89	2,074.35	2,098.72	2,247.06	4,272.12	4,099.00	6,163.25	5,085.37

From this table it is seen that the total water-soluble salts recovered from these 8 soil types range from nearly an even ton per acre in the Norfolk sand to 3 tons in the Janesville loam, distributed through the surface 4 feet of soil.

Amounts of Water-Soluble Salts Recovered from the Surface Foot.

On six different dates the surface foot of these soil types was examined for the amounts of water-soluble salts which could be recovered by single washings in distilled water and these results appear in the next table. The data here are means of the 6 determinations made upon the 5 conditions of fertilization which had been adopted for the

several areas (pages 108, 109). Each value in the table is thus a mean of 6 separate determinations, except the line of averages, and these are the mean values of 30 analyses.

Mean amounts of water-soluble salts recovered from the surface foot of eight soil types on six dates—1903.

[Salts in parts per million of dry soil.]

NORFOLK SANDY SOIL.

Fertilizer used.	Dry soil, wt. per cubic foot.	Moisture. Per cent.	Moisture. Inches.	K.	Ca.	Mg.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_2.
	Lbs.											
Nothing	88.06	13.67	2.21	9.48	37.25	11.88	14.02	7.73	51.08	20.17	3.33	11.09
5 tons manure	85.45	12.87	2.11	8.92	37.33	11.97	18.90	11.80	46.33	30.50	1.00	10.79
10 tons manure	82.63	13.47	2.39	13.29	38.25	12.59	22.32	10.73	43.17	25.67	1.00	10.19
15 tons manure	75.79	13.74	2.01	17.58	41.67	13.82	35.19	13.73	51.42	28.33	1.00	8.24
300 pounds guano	80.79	15.07	2.34	11.66	38.83	12.92	18.26	9.67	53.83	21.50	1.00	10.59
Average	82.54	13.76	2.21	12.19	38.67	12.64	21.74	10.73	49.17	25.23	1.47	10.18

SELMA SILT LOAM.

Fertilizer used.	Dry soil, wt. per cubic foot.	Moisture. Per cent.	Moisture. Inches.	K.	Ca.	Mg.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_2.
Nothing	70.54	20.49	3.14	11.08	55.33	11.66	17.67	9.95	86.33	7.50	1.00	14.55
5 tons manure	76.40	19.54	2.87	11.53	53.83	12.35	18.49	9.58	86.92	14.00	1.00	14.13
10 tons manure	75.97	18.02	2.62	12.14	52.58	13.89	25.11	13.43	81.50	16.33	1.67	10.77
15 tons manure	74.31	18.31	2.60	18.16	55.87	13.42	23.63	12.42	83.33	17.67	4.33	10.77
300 pounds guano	76.42	17.89	2.60	11.48	56.75	12.18	16.05	8.95	94.00	15.33	2.00	14.00
Average	74.73	18.85	2.77	12.88	54.87	12.70	20.19	10.87	86.42	14.17	2.00	12.84

NORFOLK SAND.

Fertilizer used.	Dry soil, wt. per cubic foot.	Moisture. Per cent.	Moisture. Inches.	K.	Ca.	Mg.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_2.
Nothing	80.82	12.21	1.92	11.61	37.92	10.75	11.49	11.00	58.33	20.00	1.00	5.09
5 tons manure	82.62	12.93	2.23	11.84	41.92	10.47	12.24	10.63	58.00	20.00	1.00	4.92
10 tons manure	83.12	13.25	2.34	12.19	39.58	10.52	13.66	11.33	52.75	22.67	1.00	5.20
15 tons manure	80.62	13.42	2.09	12.17	38.12	10.36	14.54	11.43	52.33	19.00	1.67	5.45
300 pounds guano	84.51	12.85	2.07	9.10	40.58	9.44	9.64	10.53	60.58	17.00	2.33	4.78
Average	82.34	12.93	2.13	11.38	39.62	10.31	12.31	10.98	56.40	19.73	1.40	5.09

SASSAFRAS SANDY LOAM.

Fertilizer used.	Dry soil, wt. per cubic foot.	Moisture. Per cent.	Moisture. Inches.	K.	Ca.	Mg.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_2.
Nothing	80.32	16.13	2.49	10.32	50.42	11.78	14.61	10.92	69.67	18.67	1.00	5.61
5 tons manure	75.13	16.63	2.39	10.76	54.96	11.07	18.23	10.06	70.66	25.33	2.00	6.75
10 tons manure	78.33	16.72	2.51	11.23	49.62	10.68	17.68	11.89	65.17	22.00	2.67	5.38
15 tons manure	79.22	15.88	2.42	10.48	53.17	10.75	20.71	10.02	64.67	19.33	1.00	5.60
300 pounds guano	79.13	16.40	2.45	10.78	53.79	10.45	16.35	9.86	79.00	16.00	2.67	4.76
Average	78.43	16.35	2.45	10.71	52.39	10.95	17.52	10.55	69.83	20.27	1.87	5.62

HAGERSTOWN CLAY LOAM.

Fertilizer used.	Dry soil, wt. per cubic foot.	Moisture. Per cent.	Moisture. Inches.	K.	Ca.	Mg.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_2.
Nothing	63.60	22.19	2.69	9.68	104.46	38.59	22.75	15.41	184.92	107.33	0.67	19.98
5 tons manure	64.34	24.04	2.94	11.63	101.83	40.08	25.70	16.93	188.75	115.00	.67	18.30
10 tons manure	63.87	21.72	2.66	14.53	106.96	42.28	27.52	15.79	199.17	123.00	.67	18.88
15 tons manure	66.53	22.24	2.84	18.04	118.16	46.38	29.54	15.56	225.33	134.67	1.67	18.65
300 pounds guano	66.30	23.01	2.93	14.95	139.58	51.69	43.76	19.38	325.83	155.67	.67	20.73
Average	64.93	22.64	2.81	13.77	114.20	43.80	29.85	16.61	224.80	127.13	.87	19.31

Mean amounts of water-soluble salts recovered from the surface foot of eight soil types on six dates—1903—Continued.

HAGERSTOWN LOAM.

Fertilizer used.	Dry soil, wt. per cubic foot.	Moisture.		K.	Ca.	Mg.	NO_3.	HPO_4	SO_4.	HCO_3.	Cl.	SiO_2.
		Per cent.	Inches.									
	Lbs.											
Nothing	64.83	20.87	2.60	25.84	84.58	29.32	41.59	17.75	175.42	58.33	0.33	21.48
5 tons manure	68.62	19.97	2.66	29.24	89.79	30.65	44.09	16.02	179.58	72.00	.33	23.55
10 tons manure	66.59	19.94	2.56	27.85	89.79	34.75	38.49	17.48	207.33	96.00	.67	23.08
15 tons manure	66.04	21.07	2.68	25.74	99.17	38.89	35.73	17.52	232.25	104.33	1.67	21.17
300 pounds guano	64.31	21.16	2.62	23.42	117.71	36.33	28.62	15.91	226.33	136.33	.33	23.91
Average	66.08	20.60	2.62	26.42	96.21	33.99	37.70	16.94	204.18	93.40	.67	22.64

JANESVILLE LOAM.

Fertilizer used.	Dry soil, wt. per cubic foot.	Per cent.	Inches.	K.	Ca.	Mg.	NO_3.	HPO_4	SO_4.	HCO_3.	Cl.	SiO_2.
Nothing	67.00	26.37	3.39	19.81	94.33	30.09	58.58	21.13	153.42	38.00	1.00	38.73
5 tons manure	63.79	26.59	3.25	20.23	90.25	30.62	65.70	26.53	156.66	42.67	.67	40.72
10 tons manure	64.84	27.29	3.39	20.02	96.84	28.95	59.39	32.00	134.58	41.00	.67	41.41
15 tons manure	64.56	29.39	3.65	21.05	96.71	31.23	63.28	22.93	150.67	40.66	2.67	40.28
300 pounds guano	65.89	27.68	3.46	20.02	105.83	31.11	70.59	20.23	163.33	37.33	1.33	37.71
Average	65.22	27.44	3.43	20.33	96.79	30.40	63.51	24.56	151.73	39.93	1.27	39.77

MIAMI LOAM.

Fertilizer used.	Dry soil, wt. per cubic foot.	Per cent.	Inches.	K.	Ca.	Mg.	NO_3.	HPO_4	SO_4.	HCO_3.	Cl.	SiO_2.
Nothing	71.92	20.28	2.79	14.50	90.12	27.47	52.24	17.97	144.58	34.00	0.67	35.75
5 tons manure	72.06	21.86	2.99	18.81	85.50	29.71	44.21	16.23	143.67	40.00	.67	35.07
10 tons manure	70.11	19.98	2.67	18.09	92.21	35.16	39.58	15.70	162.75	47.67	1.33	35.53
15 tons manure	69.92	21.79	2.98	15.64	91.25	28.85	37.12	16.46	140.58	32.33	.67	33.25
300 pounds guano	72.04	21.87	3.02	16.83	96.75	28.44	39.75	15.65	167.33	23.67	1.00	31.39
Average	71.21	21.16	2.89	16.77	91.17	29.93	42.58	16.40	151.78	35.53	.87	34.20

From the general averages of this table the total salts in parts per million of dry soil and in pounds per acre have been computed and they are given in the next table:

Total salts recovered from the surface foot of eight soil types—1903.

	Norfolk sandy soil.	Selma silt loam.	Norfolk sand.	Sassafras sandy loam.	Hagerstown clay loam.	Hagerstown loam.	Janesville loam.	Miami loam.
Parts per million	182.02	226.94	167.22	199.71	590.34	532.15	468.19	419.23
Pounds per acre	654.4	788.6	599.7	682.3	1,670	1,532	1,330	1,301

From the detailed results presented in the two preceding tables concerning the amounts of potash, lime, magnesia, and phosphoric acid recovered from the surface foot as well as from the surface 4 feet of these soils, it is abundantly demonstrated that large amounts of essential plant foods are carried in soils, either already in solution, or else in forms which very quickly pass into solution when the ratio of water to soil is made 5 to 1. The data presented, however, do not represent

the amounts which may be recovered with more thorough washing and especially if the washing is repeated with alternate drying of the samples.

RESULTS SECURED BY REPEATEDLY WASHING AND DRYING SAMPLES FROM THE SURFACE FOOT.

Two series of observations were made on these 8 soils types in which samples were washed 11 times by percolating through them five times their weight of water. The method of doing this was to place about Pasteur-Chamberland filters, cylinders of finely perforated copper of such diameter that a layer of soil about three-sixteenths of an inch thick could be packed within the space between the cylinder and the filter. The cylinders, thus charged, were placed in the filter chambers; water was added, and as rapidly as possible forced through the soils, after which they were at once dried.

The dry oven in the central laboratory, where this work was done, was heated with fuel gas, and to prevent the absorption of sulphuric acid the cylinders were inclosed in a small milk can and, with its tight-fitting cover on, placed in the oven, whose temperature was maintained at 120° to 125° C. When dry the soils were returned to the filter chambers, another charge of water was added, and the operation was repeated until the samples of soil had been washed 11 times. The time required to force the charges of water through the soils varied from 5 to 20 minutes, according to the texture of the samples.

The total salts recovered from the soils during the washing of each of these series are given in the next table:

Amounts of water-soluble salts recovered from eight soil types by 11 successive washings of the same samples, drying the samples between the washings—1903.

[In parts per million of dry soil.]

NORFOLK SANDY SOIL.

Series.	K.	Ca.	Mg.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_2.
First series	128.60	87.75	77.39	49.11	25.58	444.00	12	4	65.65
Second series	137.90	116.50	75.41	31.13	108.63	209.50	206	2	122.20
Average	133.25	102.13	76.40	41.12	67.11	326.78	109	3	83.93

SELMA SILT LOAM.

Series.	K.	Ca.	Mg.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_2.
First series	191.56	258.50	85.28	69.13	41.91	770.00	70	4	96.70
Second series	227.60	159.00	82.27	42.54	160.10	311.00	256	2	169.40
Average	209.58	208.75	83.78	55.84	101.01	540.50	163	3	133.05

NORFOLK SAND.

Series.	K.	Ca.	Mg.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_2.
First series	167.54	247.75	92.23	45.54	35.26	793.50	104	2	79.00
Second series	155.44	113.00	80.44	25.89	86.76	191.00	260	2	141.20
Average	161.49	180.38	86.34	35.71	61.01	492.25	182	2	110.10

Amounts of water-soluble salts recovered from eight soil types by 11 successive washings of the same samples, drying the samples between the washings—1903—Continued.

SASSAFRAS SANDY LOAM.

Series.	K.	Ca.	Mg.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_2.
First series	173.94	360.75	96.36	78.68	34.88	848.00	88	2	94.10
Second series	181.20	196.75	88.94	24.99	116.42	245.00	370	2	170.20
Average	177.57	278.75	92.65	51.84	75.65	546.50	229	2	132.15

HAGERSTOWN CLAY LOAM.

Series.	K.	Ca.	Mg.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_2.
First series	191.98	794.25	334.21	115.83	70.55	1,608.00	358	0	150.57
Second series	250.35	691.75	279.42	110.28	184.20	604.00	860	0	295.70
Average	221.17	743.00	306.82	113.06	127.38	1,106.00	609	0	223.14

HAGERSTOWN LOAM.

Series.	K.	Ca.	Mg.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_2.
First series	221.20	722.00	329.67	123.00	56.20	1,679.00	316	2	148.30
Second series	210.72	784.75	362.08	76.81	164.68	563.50	1,117	0	283.80
Average	215.96	753.38	345.88	99.91	110.48	1,121.25	716.5	1	216.05

JANESVILLE LOAM.

Series.	K.	Ca.	Mg.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_2.
First series	273.44	837.50	271.79	120.13	326.38	1,816.00	180	4	198.00
Second series	260.48	800.75	302.34	59.05	565.80	712.00	656	0	414.00
Average	266.96	819.13	287.07	89.59	396.09	1,264.00	418	2	306.00

MIAMI LOAM.

Series.	K.	Ca.	Mg.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_2.
First series	215.98	708.00	239.12	107.28	174.54	1,501.50	220	2	222.30
Second series	211.12	628.00	220.18	57.24	397.40	521.00	571	0	336.80
Average	213.55	668.00	229.65	82.26	285.97	1,011.25	395.5	1	279.55

It should be explained regarding the results of the two series that the samples of the first set were composites from the subplots to which no fertilizers had been added; while the samples of the second set were composites from the subplots to which 15 tons of stable manure had been added. Moreover, the drying of the samples following the first 6 washings of the first series was done in the open oven at 110° C. under conditions which permitted sulphuric acid, as a product of combustion of the fuel gas, to be absorbed by the soil samples; while the last 5 times drying of the first series, and all of them for the second series, were done in a closed can as described, so as so exclude all but mere traces of SO_4, as was shown by checks made at the time.

The second series of results differs also from the first series in that the first washing were made without drying, and twice the amount of water was used in the following manner: Charges of water equal to ten times the dry weights of the samples were weighed out and each divided into two lots. One-half of each of these lots of water was then at once filtered three times through the samples, which, in a sense, made 6 washings. The samples were then allowed to stand overnight

in the moist condition and the second lots of water were divided into two portions, each of which was twice filtered through the samples in quick succession, making, in a sense, 4 more washings, or 10 in all. Stated in another way 4 charges of water equal to 2.5 times the dry weight of the soils were filtered through the samples three times in quick succession; then the samples were allowed to stand, moist, overnight and 2 other similar charges twice filtered through them. All solutions were then made into single composites for determination and the results are given in the table as the first washing. The 10 other washings were made as first described.

In the next table are given the individual determinations on the same soil for both series, as an illustration of the changes which occurred during the operation:

Amounts of water-soluble salts recovered from Janesville loam at each successive washing after drying—1903.

[In parts per million of dry soil.]

FIRST SERIES.

Salts.	Determination. First.	Second.	Third.	Fourth.	Fifth.	Sixth.	Seventh.	Eighth.	Ninth.	Tenth.	Eleventh.	Total.
K	20.32	20.96	19.12	19.12	20.56	18.76	33.68	45.60	26.40	29.60	20.32	273.44
Ca	72.00	58.00	49.00	65.00	78.00	70.00	260.00	80.00	46.00	36.00	23.50	837.50
Mg	21.95	19.68	23.46	32.36	18.02	17.12	63.40	36.42	13.92	10.70	14.76	271.79
NO_3	82.60	10.08	4.32	5.34	3.95	5.04	6.98	1.82	0.00	0.00	0.00	120.13
HPO_4	7.20	11.80	11.40	9.50	11.10	9.72	42.88	43.10	31.38	24.90	23.40	226.38
SO_4	104.00	204.00	208.00	240.00	216.00	220.00	410.00	128.00	52.00	26.00	8.00	1,816.00
HCO_3	14.00	14.00	12.00	16.00	14.00	18.00	20.00	12.00	24.00	20.00	16.00	180.00
Cl	4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00
SiO_2	17.50	21.30	20.30	24.00	19.40	20.00	17.90	10.60	13.00	12.80	21.20	198.00
Sum	343.57	359.82	347.60	413.32	381.03	380.64	854.84	337.54	206.70	160.00	127.18	....

SECOND SERIES.

Salts.	First.	Second.	Third.	Fourth.	Fifth.	Sixth.	Seventh.	Eighth.	Ninth.	Tenth.	Eleventh.	Total.
K	25.04	23.52	34.16	30.00	28.72	29.60	17.76	17.44	17.44	18.40	18.40	260.48
Ca	88.00	140.00	150.00	118.00	98.00	48.75	48.00	35.00	35.00	20.00	20.00	800.75
Mg	22.82	55.22	68.48	47.54	25.17	19.02	18.61	12.81	12.81	9.43	9.43	302.34
NO_3	42.72	5.04	2.75	0.00	0.00	0.00	1.21	1.40	1.39	2.27	2.27	59.05
HPO_4	31.60	36.90	75.80	78.50	77.40	73.70	49.00	38.20	38.20	33.25	33.25	565.80
SO_4	118.00	152.00	244.00	92.00	56.00	7.00	26.00	5.50	5.50	3.00	3.00	712.00
HCO_3	80.00	35.00	30.00	110.00	155.00	28.00	38.00	44.00	44.00	46.00	46.00	656.00
Cl	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SiO_2	41.10	26.00	31.20	32.60	45.10	34.50	42.80	42.30	42.30	38.30	38.30	414.50
Sum	449.28	473.68	636.34	508.64	485.39	240.57	241.38	192.64	192.64	170.65	170.65	....

It is to be noted that in both of these series there is a general tendency for the total salts to decrease with successive washings, but only the nitrates and chlorine are reduced to zero in this soil type. In the four Southern soils the lime recovered was reduced to zero or became very small, and the SO_4 also became small.

In the first series, after drying at the temperature of 120°, instead of 110°, in the closed can, there was, at first, an abrupt increase in the amounts of all ingredients recovered except HCO_3 and SiO_2, and

the increase was notably large in both Ca and SO_4, although the absorption of gases from the oven had been practically excluded. But after the first drying following the change, both the Ca and the SO_4 decrease again rapidly.

In the second series the eighth and ninth and also the tenth and eleventh washings were thrown together and determined as composites, but they have been arbitrarily expressed separately in the table by dividing the results by two.

The first column in the section of the table for the second series expresses the salts recovered by the first washing which was done without previously drying the sample as already stated.

In the next table there have been brought together the mean amounts of the salts recovered by the single and by the repeated washing of the soils, to contrast the results.

Amounts of salts recovered from the surface foot of 8 soil types by single and by repeated washings—1903.

[In parts per million of dry soil.]

NORFOLK SANDY SOIL.

Treatment.	K.	Ca.	Mg.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_2.
Washed 11 times	133.25	102.13	76.40	41.12	67.11	326.78	109.00	3.00	83.93
Washed once	12.19	38.67	12.64	21.74	10.73	49.17	25.23	1.47	10.18
Difference	121.06	63.46	63.76	19.38	56.38	277.61	83.77	1.53	73.75

SELMA SILT LOAM.

Treatment.	K.	Ca.	Mg.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_2.
Washed 11 times	209.58	208.75	83.78	55.84	101.01	540.50	163.00	3.00	133.05
Washed once	12.88	54.87	12.70	20.19	10.87	86.42	14.17	2.00	12.84
Difference	186.70	153.88	71.08	35.65	90.14	454.08	148.83	1.00	120.21

NORFOLK SAND.

Treatment.	K.	Ca.	Mg.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_2.
Washed 11 times	161.49	180.38	86.34	35.71	61.01	492.25	182.00	2.00	110.10
Washed once	11.38	39.62	10.31	12.31	10.98	56.40	19.73	1.40	5.09
Difference	150.11	140.76	76.03	23.40	50.03	435.85	162.27	.60	105.01

SASSAFRAS SANDY LOAM.

Treatment.	K.	Ca.	Mg.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_2.
Washed 11 times	177.57	278.75	92.65	51.84	75.65	546.50	229.00	2.00	132.15
Washed once	10.71	52.39	10.95	17.52	10.55	69.83	20.27	1.87	5.62
Difference	166.86	226.36	81.70	34.32	65.10	476.67	208.73	.13	126.53

HAGERSTOWN CLAY LOAM.

Treatment.	K.	Ca.	Mg.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_2.
Washed 11 times	221.17	743.00	306.82	113.06	127.38	1,106.00	609.00	0.00	223.14
Washed once	13.77	114.20	43.80	29.85	16.61	224.80	127.13	.87	19.31
Difference	207.40	628.80	263.02	83.21	110.77	881.20	481.87	+.87	203.83

Amounts of salts recovered from the surface foot of 8 soil types by single and by repeated washings—1903—Continued.

HAGERSTOWN LOAM.

Treatment.	K.	Ca.	Mg.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_2.
Washed 11 times	215.96	753.38	845.88	99.91	110.48	1,121.25	716.50	1.00	216.05
Washed once	26.42	96.21	33.99	37.70	16.94	204.18	93.40	.67	22.64
Difference	189.54	657.17	311.89	62.21	93.54	917.07	623.10	.33	183.41

JANESVILLE LOAM.

Treatment.	K.	Ca.	Mg.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_2.
Washed 11 times	226.96	819.13	287.07	89.59	396.09	1,264.00	418.00	2.00	306.00
Washed once	20.23	96.79	30.40	63.51	24.56	151.73	39.93	1.27	39.77
Difference	206.73	722.34	256.67	26.08	371.53	1,112.27	378.07	.73	266.23

MIAMI LOAM.

Treatment.	K.	Ca.	Mg.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_2.
Washed 11 times	213.55	668.00	229.65	82.26	285.91	1,011.25	395.50	1.00	279.55
Washed once	16.77	91.17	29.93	42.58	16.40	151.78	35.53	.87	34.20
Difference	196.78	576.83	199.72	39.68	269.51	859.47	359.97	.13	245.35

From this table it will be seen that the repeated washings have resulted in recovering from 8 to 16 times as much potash, from 3 to 8 times as much lime, from 6 to 10 times as much magnesia, from 1 to 3 times as much nitric acid, from 5 to 16 times as much phosphates, and from 5 to 8 times as much sulphates as were obtained, on the average, from the single washings.

It will be further clear from the data of the table that, both absolutely and as percentages, notable differences are shown by the repeated washing of the different soil types. If we take the largest amount of each ingredient recovered from any soil as 100 per cent, the amount recovered from the others stand as indicated below:

Relative amounts of 5 essential elements of plant food recovered from 8 soil types by washing 11 times, on basis of 100 for the highest—1903.

Salts.	Norfolk sandy soil.	Selma silt loam.	Norfolk sand.	Sassafras sandy loam.	Hagerstown clay loam.	Hagerstown loam.	Janesville loam.	Miami loam.
Potash (K)	49.37	77.45	59.92	65.83	81.83	80.00	100.00	79.11
Lime (Ca)	12.18	25.49	22.07	34.04	90.71	91.97	100.00	81.55
Magnesia (Mg)	22.09	24.22	24.96	26.78	88.70	100.00	83.00	66.01
Nitrogen (NO_3)	36.36	49.37	31.68	45.84	100.00	88.34	79.21	72.73
Phosphorus (HPO_4)	16.94	25.50	15.40	19.10	32.16	27.90	100.00	72.18
Sulphur (SO_4)	25.86	42.76	38.95	43.24	87.50	88.69	100.00	79.99

A corresponding comparison of the same ingredients recovered from these soils by the single washing gives the results next tabulated.

Relative amounts of 5 essential elements of plant food recovered from 8 soil types by a single washing in distilled water, on the basis of 100 for the highest—1903.

Salts.	Norfolk sandy soil.	Selma silt loam.	Norfolk sand.	Sassafras sandy loam.	Hagerstown clay loam.	Hagerstown loam.	Janesville loam.	Miami loam.
Potash (K)	46.14	48.74	43.08	40.54	52.12	100.00	76.56	63.47
Lime (Ca)	33.86	48.05	34.69	45.87	100.00	84.23	84.75	79.83
Magnesia (Mg)	28.86	29.00	23.54	25.00	100.00	77.60	69.41	68.33
Nitrogen (NO_3)	34.23	31.81	19.39	27.59	47.00	59.36	100.00	67.05
Phosphorus (HPO_4)	43.71	44.28	44.72	42.98	67.66	69.00	100.00	66.80
Sulphur (SO_4)	17.37	38.45	25.09	31.06	100.00	90.84	67.48	67.53

It will be seen from these comparisons that the maximum amounts of each of the 5 essential plant foods recovered from the 8 soil types were all recovered from one or the other of the same three soil types, and there can be no question but that these three types possess the greatest capabilities of crop production. In the repeated washings the Janesville loam leads all of the other soils in each essential plant food except two, and it has produced the largest yields both of corn and of potatoes during this year.

Amounts of Water-Soluble Salts Recovered from Soils by Continuous Percolation without Drying.

In extension of the work just described, two of the same soils were washed by the continuous percolation through them of 8,000 cc of distilled water, without drying, the time required being about five hours. The same apparatus was used and samples from 2 of the same lots of soils as those employed in the second series of the last section, 138.2 grams, water-free, of the Hagerstown loam and 176.2 grams of the Norfolk sand being required to fill the respective perforated jackets surrounding the filters. The solutions when analyzed gave the results in the next table:

Amounts of water-soluble salts recovered from 2 soils by the continuous percolation of 8,000 cc of distilled water through them—1903.

[In parts per million of dry soil.]

Soil.	K.	Ca.	Mg.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_2.
Hagerstown loam	91.25	165.59	116.59	95.65	88.93	324.24	856.92	57.90	40.21
Norfolk sand	43.40	48.12	67.59	26.60	32.91	125.30	163.44	45.40	17.34
Difference	47.85	117.47	49.00	69.05	56.02	198.94	693.48	12.50	22.87

From these results it is clear that large amounts of the different salts are present in these soils in such form that they may be recovered without drying by rapidly percolating water continuously through very thin layers of them.

It will be well to bring into comparison the amounts recovered from these 2 soils under the several treatments to which they have been subjected.

Water-soluble salts recovered by four different methods of treatment from 2 soils by using distilled water—1903.

[In parts per million of dry soil.]

NORFOLK SAND.

Method of treatment.	K.	Ca.	Mg.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_2.
First method	11.38	39.62	10.31	12.31	10.98	56.40	19.73	1.40	5.09
Second method	16.28	23.00	12.04	17.52	6.76	54.00	24.00	2.00	12.70
Third method	43.40	48.12	67.59	26.60	32.91	125.30	163.44	45.40	17.34
Fourth method	155.44	113.00	80.44	25.89	86.76	191.00	260.00	2.00	141.20

HAGERSTOWN LOAM.

Method of treatment.	K.	Ca.	Mg.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_2.
First method	26.42	96.21	33.99	37.70	16.94	204.18	93.40	.67	22.64
Second method	15.76	110.00	38.04	55.84	14.40	140.00	284.00	0.00	28.30
Third method	91.25	165.59	116.59	95.65	88.93	324.24	856.92	57.90	40.21
Fourth method	210.72	784.75	362.08	76.81	164.68	563.50	1,117.00	0.00	283.80

In this table the figures for the first method are the averages of all the field determinations for the surface foot in which the soils were washed by stirring in a mortar three minutes in 5 times their weight of distilled water.

The second method is the one described on page 69, where water equal to 10 times the weight of the soil was used, but not continuously.

The third method is the one just described, where the water percolated continuously and was used in the ratio of about 45 to 50 to 1 of soil, the water traversing but once a thin layer of soil.

The fourth method is the one where the same sample was washed 11 times, using each time water equal in weight to 5 times that of the soil, or, all told, 55 times the dry weight of the soil, but with the additional effect of drying at 120° to 125° C. between the washings.

It is worthy of special note here that with both soils by the second method, where the solution was repeatedly passed through the sample, little more salts have been recovered, although twice the amounts of water were used. This is in accordance with the preliminary observations already cited (page 32) on the impracticability of using well water instead of distilled water in which to wash the samples, and with the long-established absorptive power of soils.

In a second series of observations along these lines, samples of the Janesville loam and of the Norfolk sand were used, taken from bulk lots of soil with which had been thoroughly incorporated about six months previously fresh cow manure at the rate of 200 tons per acre, and which had been maintained under optimum moisture conditions.

The samples were handled in the manner described above, but using 6,000 cc of distilled water. These samples, never having been dried, allowed the water to percolate through them at a much slower rate, the time required being about thirty-six hours, the pressure maintained on the Norfolk sand being enough lower to give the same rate of percolation for both soils.

In each case the last 1,000 cc was collected and determined separately from the first 5,000 cc, and the results appear in the next table:

Water-soluble salts recovered from 2 soils by the continuous percolation of 6,000 cc of distilled water—1903.

[In parts per million of dry soil.]

JANESVILLE LOAM.

Water used.	K.	Ca.	Mg.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_2.
First 5,000 cc	96.23	87.33	81.15	189.40	54.62	205.55	328.59	41.91	12.65
Last 1,000 cc	8.39	7.23	11.97	4.46	8.64	16.78	43.63	8.39	5.04
Total	104.62	94.56	93.12	193.86	63.26	222.33	372.22	50.30	17.69

NORFOLK SAND.

Water used.	K.	Ca.	Mg.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_2.
First 5,000 cc	56.48	59.98	57.16	143.93	31.83	109.97	373.83	32.42	13.24
Last 1,000 cc	5.76	4.21	9.44	2.96	5.05	8.29	28.51	6.48	2.14
Total	62.24	64.19	66.60	146.89	36.88	118.26	402.34	38.90	15.38

It will be seen from these data that large amounts of the essential plant foods have been recovered from these soils; moreover, that, notwithstanding the fact that the amounts of manure added to these soils were precisely the same, the solutions recovered from them after six months are strongly contrasted; indeed, almost as much so as if equal and large amounts of soluble salts had not been added to them. It is also clear from the data that the last 1,000 cc of solution passing through the soils were notably weaker than the first, and that the soils were then yielding less salts than are normal to the untreated field soils.

In still another case a naturally poor soil, but one which had been heavily manured and had matured a large crop, was examined by the ordinary field method—washing by stirring in the mortar three minutes with water in the ratio of 5 to 1. The soil had been used on one of the benches of a Government forcing house for chyrsanthemums and was prepared by mixing stable manure with the soil in the proportion of "one barrel of manure to three barrels of soil." The soil was prepared early in May and analyzed November 1. The method of watering had led to much and frequent leaching and a very heavy close stand of plants had matured upon the ground. The results obtained appear in the next table.

Water-soluble salts recovered from a soil six months after heavy manuring—1903.

[In parts per million of dry soil.]

Soil.	K.	Ca.	Mg.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_2.
Greenhouse soil	122.00	125.00	67.28	299.74	103.80	355.00	36.00	75.00	18.90

Here is a soil which, after much leaching and having matured a heavy crop, still yields, by washing once and but three minutes with distilled water, large amounts of the essential plant foods. Enough both of potash and of phosphoric acid have been recovered from this soil to represent between 300 and 400 pounds per acre for the surface foot.

AMOUNTS OF DISSOLVED SALTS CARRIED IN WELL AND DRAINAGE WATERS.

In order to compare the water-soluble salts of soils with the drainage water of the same region, several waters were examined at different times during the season of 1902, both at Goldsboro, N. C., and at Madison, Wis., where soil studies were being made.

In the three fields at Goldsboro, whose soluble salts were investigated during the season, wells were bored with a 4-inch auger at the places where the soil samples were being taken in order to be able to collect the ground water. These were cased at the top with galvanized-iron casings provided with covers, and at intervals during the season samples of the waters contained were analyzed, together with those collected from ditches, local creeks, and streams.

From the three soil types, Nos. 1, 2, and 3, of the table following, water was collected on June 6, 12, 19, and 26, July 2 and 28, and August 28, and the values given in the table are the means of the seven determinations. Nos. 1, 2, and 3 are in Goldsboro compact sandy loam, Selma silt loam, and Norfolk sandy soil, respectively. No. 4 was water taken from a fresh hole made with the soil tube in an oat field on Selma silt loam.

No. 5 is from an open ditch in the same soil adjacent to the field where No. 4 was taken. Nos. 6 and 7 are both from open ditches in the Norfolk sandy soil, the former being immediately adjacent to the area of Norfolk sandy soil used in 1903. No. 8 is from an open ditch lying at the foot of a terrace separating an area of Norfolk sandy soil from Selma silt loam, and the water may possibly represent underdrainage from the higher ground. No. 9 is from an open ditch in Selma silt loam 100 feet farther from the terrace than No. 8. Nos. 7 to 9 were all collected on May 21 and represent single determinations. There had been no rain since the 15th, on which date 0.27 inch fell.

Nos. 10, 11, and 12 are from local small streams deriving all of their water from one or more of the three soil types named above, and samples were collected from each on May 10 and 21, June 6, 12, 19, and 26, July 2 and 28, and August 28. The results are the averages of these nine determinations.

Nos. 13 and 14 are from the Neuse River and its tributary the Little River, the former being the tap water of the laboratory taken from the city water supply. Samples were taken on the same dates as for Nos. 10, 11, and 12 and the results are the averages.

No. 15 was taken from the ice-plant well of the city of Goldsboro, which is something over 200 feet deep, and the values in the table are averages of determinations made on the same 9 dates as in case of the river waters.

No. 16 is water from a line of tile-drains under a piece of black marsh soil on the Experiment Station farm of the University of Wisconsin. The values are the means of two determinations, both made near the middle of July.

No. 17 is from a dug well in a glacial drumlin on the campus of the University of Wisconsin; the water table is 52 feet above Lake Mendota, and the water must be strictly local. The well is between 40 and 50 feet deep.

No. 18 is from a drilled well 60 feet deep extending into the potsdam sandstone and adjacent to the university campus. The values against this and the next preceding number are averages of 6 and 2 determinations, respectively. All of the Madison determinations were made by Dr. Herman Schlundt and Dr. R. D. Hall, Doctor Schlundt having charge of the work done there in 1902.

In the table which follows are given the results from the various sources.

Amounts of soluble salts carried by ground, drainage, and well waters—1902.

[In parts per million of water.]

Sample No.	Source of water.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_3.
1	Ground water	14.55	1.56	0.80	1.57	16.75	4.75
2	.....do	15.46	1.54	7.43	1.45	11.20	7.21
3	.....do	9.63	1.22	.80	1.14	6.25	4.81
4	.....do	4.95	8.92	11.81	1.82	7.74	7.61
5	Open ditch	.51	2.16	10.86	3.03	4.22	6.68
6	.....do	14.14	2.71	13.52	2.05	9.14	4.41
7	.....do	1.62	8.92	5.52	4.84	4.22	6.94
8	.....do	.40	2.70	6.28	6.04	7.74	4.14
9	.....do	.85	6.22	16.77	3.63	14.07	8.01
10	Small stream	.90	1.82	3.29	2.21	4.49	5.38
11	.....do	.43	1.77	1.34	2.21	2.26	2.72
12	.....do	.87	1.85	4.11	2.52	4.04	5.11
13	Neuse River	.38	1.53	5.28	2.32	3.92	9.79
14	Little River	.53	2.05	3.07	2.30	3.66	10.89
15	Ice plant well	.72	2.31	26.46	2.86	44.32	10.02
16	Tile drain	4.42	7.29	13.25	340.56	3.03	1.56
17	Dug well	20.44	4.76	12.21	373.48	39.92	....
18	Drilled well	9.24	4.61	24.99	348.35	6.13	1.44

It will be seen from the data of this table that ground waters have a higher content of nitric acid than running waters do; No. 6, however, is an exception. The Wisconsin waters are enormously higher in the so-called bicarbonates, if we except the ice-plant well; but they are lower in silica and chlorine if we except the well on the University of Wisconsin campus, No. 17, which is also very high in nitric acid.

PLANT FOOD REMOVED FROM SOILS BY CROPS COMPARED WITH THE AMOUNTS RECOVERED BY DISTILLED WATER.

To show the relation between the amounts of plant food which have been recovered from these different soil types, using distilled water, and those which are removed by crops, the amounts of potash, lime, magnesia, nitrogen, and phosphorus, shown by analysis to exist in 1 ton of clover hay has been taken as a standard for comparison. These amounts, according to Wolff's tables, are given below:

Amounts of plant food removed from soil by 2,000 pounds of clover hay.

	Pounds.
Potash (K)	30.92
Lime (Ca)	28.72
Magnesia (Mg)	7.60
Nitrogen (N)	39.40
Phosphorus (P)	4.89

Using the values found for the surface 4 feet of soil, as recorded in the table on page 65, there has been computed the number of tons of clover hay which will contain the amounts of the different plant foods removed from these soils by washing three minutes in distilled water, the values being derived from the mean values for the eight soil types.

Number of tons of clover hay required to contain the mean amounts of plant food per acre recovered from the surface 4 feet of 8 soil types.

Elements of plant food.	Recovered from 1 acre.	Clover hay.
	Pounds.	*Tons.*
Potash (K)	223.58	7.23
Lime (Ca)	705.93	24.58
Magnesia (Mg)	262.88	34.59
Nitrogen (N)	106.01	2.69
Phosphorus (P)	65.78	13.21

From this table it is seen that, from the surface 4 feet of soil, there has been recovered per acre enough nitrogen, by the three-minute washing, for a crop of 2½ tons of clover hay. Of potash, there was enough recovered for two, and of phosphorus, enough for about five such crops.

The amounts recovered from the surface foot of soil alone would not differ very much from one-fourth the values given above. If the amounts recovered by repeated washing with distilled water, with alternate dryings between the washings, and those recovered by continuous percolation, without drying, are compared with the drain of clover upon the land, the results will be much more favorable to the soil than those just stated.

PART II.—RELATION OF CROP YIELDS TO THE AMOUNTS OF WATER-SOLUBLE PLANT-FOOD MATERIALS RECOVERED FROM SOILS.

In Part I of this bulletin have been presented the results of two seasons' investigations relating to the amounts of plant-food materials and other water-soluble salts which could be recovered from different soil types and from the same soil types under different conditions by bringing them into contact with distilled water for a very brief period only.

The whole work, there recorded, has been, in its fullest sense, a field study, aiming to reach the then existing conditions. The prime object was the fullest attainable knowledge of the character of the soil solution and a correlation of this character with different soil types, with different methods of soil management, and with the yields of crops. In carrying out that study the work was so planned that, as far as possible, the soluble-salt determinations were made in connection with some crop whose yields were ascertained and whose growth was under observation.

It is the purpose of this paper to present those observations, made during 1902 and 1903, which were definitely related to the field crops whose conditions or relative yields were ascertained.

RELATION OF YIELDS TO THE TOTAL SALTS CARRIED IN UNDERDRAINAGE WATER.

While the amounts of salts in waters carried away from fields by the underdrainage do not represent the amounts which are carried in the soil moisture of those fields, it will probably be conceded that those soils whose underdrainage carries relatively large amounts of salts themselves contain stronger soil solutions than do those whose drainage waters are more dilute. Due regard will be given, of course, to proper limitations, excluding underflows whose waters have never passed through the soil of the field.

The composition of the drainage water of the Rothamsted Broadbalk field has been given (page 24), and here are brought into comparison the yields from the various plots of that field.

Relation of Yield to Composition of Drainage Water from Broadbalk Field.

If we arrange the yields of grain and straw from the Broadbalk fields in a decreasing series and bring into the same table with the

yields of wheat, the total solids found in the drain water, and the sums of the lime, magnesia, and nitric acid from the different plots, they will appear as in the following table:

Relation of crop yields to total solids in drain water from Broadbalk Fields, Rothamsted.

No. of plot.	Crop yield of fields.		Contents of drainage waters, in parts per million of water.	
	Total crop yield per acre.	Yield of grain per acre.	Total solids.	Nitrates, lime, and magnesia.
	Pounds.	*Pounds.*		
9	6,920	2,175	423.9	142.4
2	5,304	1,890	476.1	168.4
7	5,013	1,688	492.4	202.7
13	4,964	1,703	544.3	228.1
14	4,716	1,673	598.6	257.5
12	4,493	1,590	530.9	215.3
11	3,716	1,350	425.9	190.2
10	2,904	1,080	406.9	175.4
6	3,348	1,215	407.6	160.3
5	1,984	765	326.0	135.8
3 & 4	1,726	675	246.4	107.1

In this table, beginning at the bottom with the lowest figures, there is a progessive increase of all values up to and including the seventh line, but from here both the figures representing total solids and those representing nitric acid, lime, and magnesia decrease, while the yields per acre go on increasing. The relations existing are more clearly shown in the accompanying graphic representation (fig. 4). It appears not wholly unreasonable to regard the falling down of the curves, for the solids in the drain water from plots 13, 7, 2, and 9, over which the yields of crops have increased, as suggesting a direct causal relation between the decrease in salt contents of the drainage waters and the larger yields; for, if there has not been enough readily soluble plant food carried by the soils of some plots to permit strong growth to take place, it would be expected that the yields would increase with an increase in the strength of the solution until the rate of growth and its magnitude became great enough to actually so reduce the water-soluble salts that there would be less left to drain away, these salts having become concentrated in the growing crop where they may influence the yield instead of being lost in the drainage water.

It is recognized that the times of collecting the drainage waters for the data here used and the number of determinations may have been such as to leave little weight to the suggestion just made. It should also be remarked that in arranging the data we have taken the yields of that part of plot 9, known as 9 (a), rather than those of that part known as 9 (b), or the averages of the two, which might, perhaps, better have been taken. If plot 9 was divided lengthwise for cropping purposes, as we suppose to have been the case, it is not impossible that the drainage water may have entered the drain chiefly or even wholly from the (b) side. Were this the case, the (b) yields should be

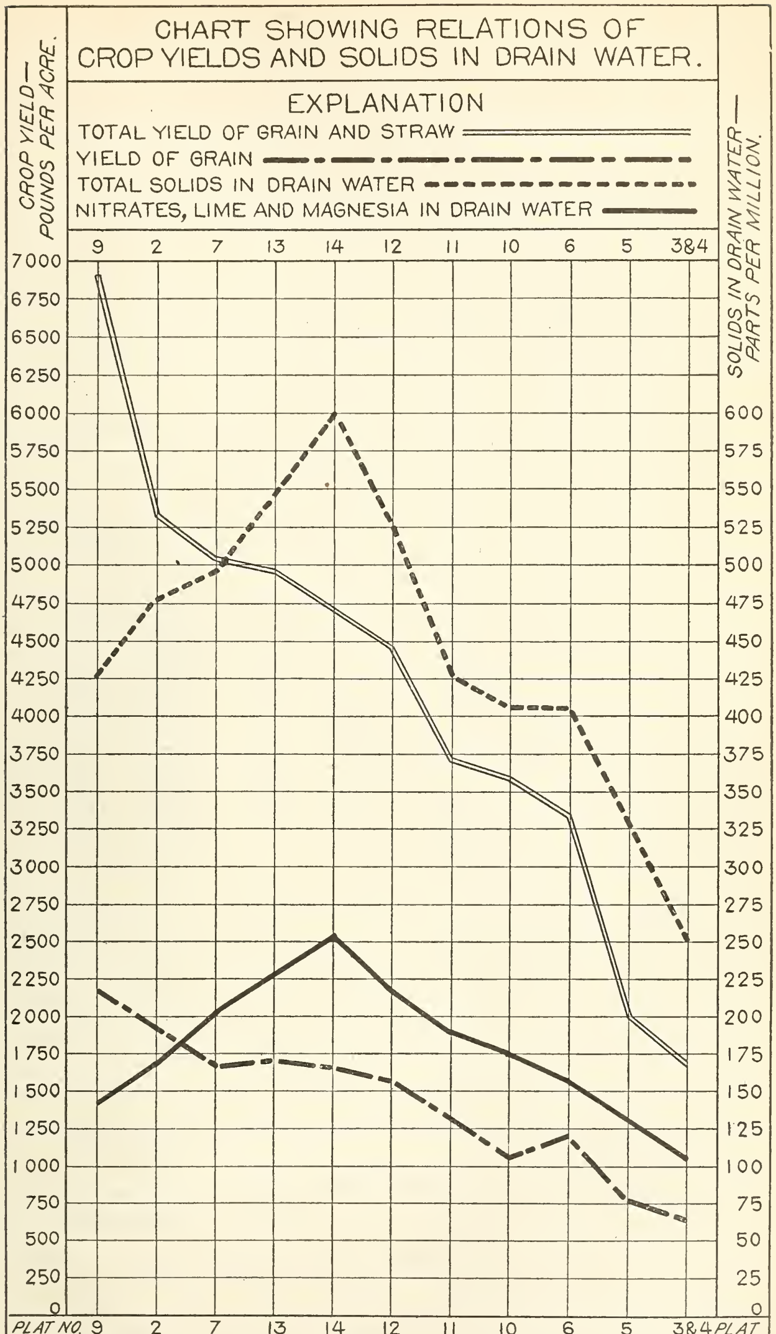


FIG. 4.—Chart showing relations of crop yields and solids in drain water from plots of Broadbalk field, Rothamsted, England. Plots are arranged in order of yield of grain and straw from lowest at right to highest at left.

used in constructing the curves and this would place plot 9 between 11 and 10 and reduce by one the cases where a larger yield has been associated with the smaller amount of solids in the drainage water.

The yields of total crop on the extreme plots—3 & 4, and 13—stand in the ratio of 1 to 2.87, and the yields of grain stand in the ratio of 1 to 2.57, while the total solids in the drainage water from the same plots stand in the ratio of 1 to 2.21, and some such relations as these should be expected if the amounts of water-soluble salts in soils materially influence yields.

If the plots are arranged in the order of the total fertilizers added to the respective areas, regardless of their composition, and the total yields and total solids in the drainage water are grouped in the same order, they will appear as shown in the next table:

Relation between the amounts of fertilizers added and the total solids in the drainage waters, Broadbalk fields, Rothamsted, England.

No. of plot.	Fertilizers added.	Total solids in drainage water.	Total yields.
	Pounds per acre.	*Parts per million.*	*Pounds per acre.*
8	1,049	548.4	6,219
12	901	530.9	4,493
7	890	492.4	5,013
15	832	585.3	4,826
13	751	544.3	4,964
6	733	407.6	3,348
14	701	598.6	4,716
2	696	476.1	5,304
5	574	326.0	1,984
9	571	423.9	3,587
11	566	425.9	3,716
10	316	406.9	2,904
16	....	286.7	2,131
3 & 4	....	246.4	1,726

The relations of these three series of values are most readily seen in the graphic representation (fig. 5). In constructing this diagram we have used the yields for the (b) portion of plot 9 instead of the (a) portion, as was done in figure 4. It will be seen that not only is there a general relation between the amounts of fertilizers added to these plots and the total solids being carried away in the drainage water, but also that there is a well-marked tendency for the curve of salts to rise and fall with the total yields from the respective plots, there being but one exception in the series.

Attention should be called to the relation between the yields on plots 3 & 4 and 16 (to which no manure or fertilizers were added) and the amounts of total salts in the drainage water from them. It will be seen that the yield from plot 16 is 23 per cent larger than that from plots 3 & 4 while the salts are 16 per cent larger in the drainage waters.

It is needful to emphasize here, to avoid misunderstanding, that it is not intended to convey the impression that the mere quantity of dissolved salts in the soil moisture about the roots of growing crops is

believed to be a factor influencing yield. The questions, which an attempt is now being made to answer, are: (1) What amounts of water-soluble salts are carried by different soil types? (2) Are yields quantitatively related to the amounts and character of these salts or to any variation in their relative proportions?

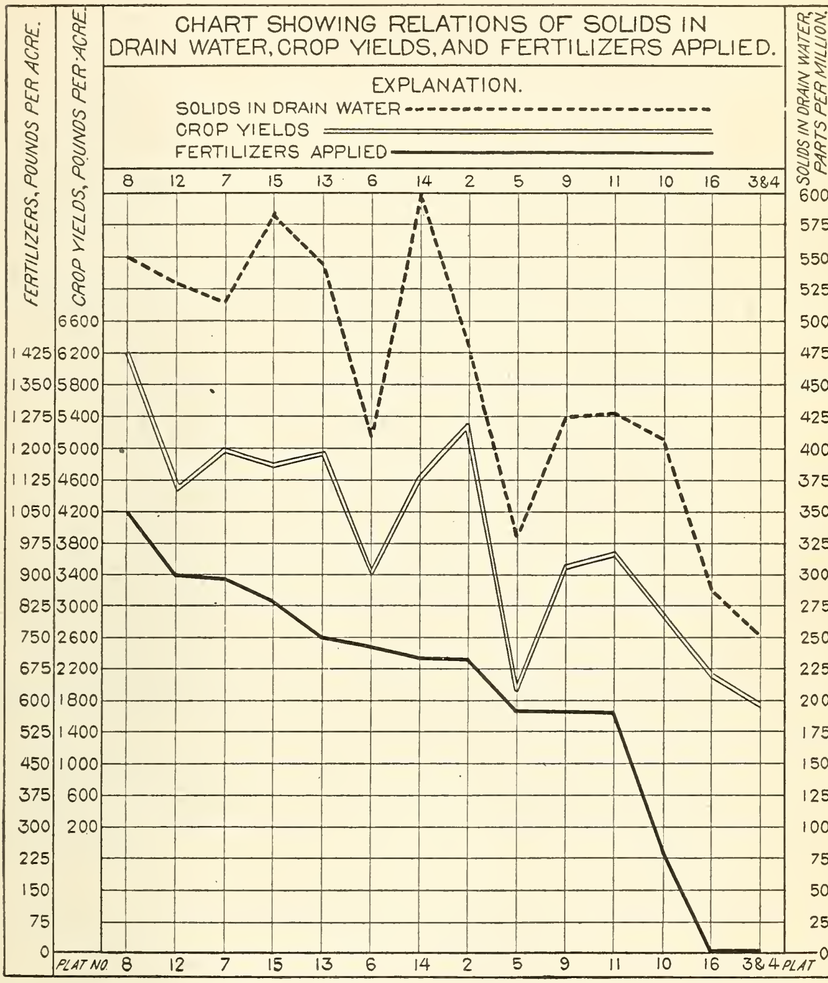


FIG. 5.—Chart showing relations of solids in drain water, crop yields, and fertilizers applied, in experiments at Rothamsted, England. Plots are arranged in order of fertilizers applied from lowest at right to highest at left.

RELATION BETWEEN YIELDS AND TOTAL SALTS IN WELL AND DRAINAGE WATERS AT GOLDSBORO, N. C., AND AT MADISON, WIS.

There have been given in Part I of this Bulletin, page 77, observations showing the amounts of salts, as indicated by the negative radicals determined, carried in solution in ground and drainage water at Goldsboro, N. C., and at Madison, Wis.

Gravimetric determinations of the total solids in the waters of Nos. 1, 2, 3, and 15 of the table referred to showed the following amounts:

Total salts in ground and well waters, as indicated by gravimetric determinations—1902.

[In parts per million of water.]

Source of water.	No.	Dried at 110° C.	Dried at 230° C.
Goldsboro compact sandy loam	1	93	74
Selma silt loam	2	72	67
Norfolk sandy soil	3	65	45
Ice-plant well	15	274	274.5

The Madison, Wis., waters are known to contain from 350 to 550 parts per million of total salts, as indicated by gravimetric determination.

The mean amounts of the negative radicals for the 3 soil waters at Goldsboro and for the drainage waters at Madison are given in the next table.

Mean amounts of salts in Goldsboro, N. C., and Madison, Wis., drainage waters, as indicated by the negative radicals determined—1902.

[In parts per million of water.]

Locality.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_3.
Madison, Wis	4.42	7.29	13.25	340.56	3.03	1.56
Goldsboro, N. C	13.21	1.44	3.01	1.39	11.40	5.59
Difference	−8.79	5.85	10.24	339.17	−8.37	−4.03

It will be seen that the salts, whatever they may be, indicated by the HCO_3, are enormously larger in amount in the Madison waters, and that the total solids are in the ratio of 370 to 36.

The yields of corn and potatoes from the soils of the two regions, under similar treatments, have been for the years 1902 and 1903 from 2 to 2.5 times on the Madison soils what they were on those in the Goldsboro district.

RELATION OF YIELDS TO WATER-SOLUBLE SALTS IN SOILS AT MADISON AND STEVENS POINT, WIS.

In 1901 [a] a comparative study was made of yields on a medium clay loam on the university farm at Madison, Wis., and on a rather coarse sandy soil at Stevens Point, Wis., growing both corn and potatoes under ordinary and under irrigated conditions. In the following table are given the comparative yields of the 2 crops on the 2 soils under the different conditions:

[a] United States Department of Agriculture, Office of Experiment Stations, Bulletin 119, p. 113.

Comparative yields from medium clay loam and on coarse sandy soil—1901.

[In bushels per acre.]

Soil.	Corn.		Potatoes.	
	Not irrigated.	Irrigated.	Not irrigated.	Irrigated.
Medium clay loam	30.14	65.30	220.9	383.6
Coarse sandy soil	27.28	36.03	82.0	130.4
Difference.	2.86	29.27	138.9	253.2

The season had been a dry one, and more so, relatively, at Madison than at Stevens Point.

In the summer of 1902 the water-soluble salts, so far as the negative radicals are concerned, were determined for comparison on these same soils, and the mean results are given in the next table:

Water-soluble salts recovered from 2 soil types—mean, per foot, for the surface 4 feet—1902.

[In parts per million of dry soil.]

Soil.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_3.	Total.
Medium clay loam	6.80	5.16	19.53	24.15	3.74	23.71	83.09
Coarse sandy soil	5.10	8.75	3.42	15.16	.74	5.23	38.40
Difference	1.70	−3.59	16.11	8.99	3.00	18.48	44.69

If the yields of corn and potatoes, in bushels per acre, are averaged for the two types of soil, they stand in the ratio of 174.99 to 68.93, or as 2.54 to 1. The total negative radicals stand in the ratio of 83.09 to 38.40, or as 2.17 to 1.

The three bases—potash, lime, and magnesia—determined in the Janesville and Miami loam in 1903, constituted 31.5 per cent of the negative radicals. If we use this relation for the two soil types under consideration, and a mean dry weight of 4,000,000 pounds per acre-foot for the Madison soil and 4,400,000 for the coarse sandy soil, the differences in the amounts of salts for the surface 4 feet will stand as here stated.

Difference in total salts per surface 4 feet of two Wisconsin soils.

[In pounds per acre.]

	Medium clay loam.	Coarse sandy soil	Difference.
Computed potash, lime, and magnesia in 4 feet	417.72	212.96	204.76
Observed negative radicals in 4 feet	1,329.44	675.84	653.60
Total per acre in 4 feet	1,747.16	888.80	858.36

The total salts indicated as recovered from the soil giving the larger yields are, therefore, about double the amount shown in the poorer soil.

RELATION OF YIELDS TO THE AMOUNTS OF WATER-SOLUBLE SALTS IN SOILS AT GOLDSBORO, N. C.

The correlation of yield with the water-soluble salts, presented in this section, relates to the investigations made in 1902, chiefly upon 3 soil types in the vicinity of Goldsboro, N. C. The general methods of procuring the data are stated on pages 26–30.

Relation of Yields to Amounts of Water-Soluble Salts in three Soil Types.

The 3 types of soil here compared are the Selma silt loam, Norfolk sandy soil, and the Goldsboro compact sandy loam, and the amounts of water-soluble salts in them were determined on 8 dates between April 23 and September 28. The moisture condition of the soil, for each of the surface 4 feet, and the amounts of salts recovered during each month are given on pages 38–40, preceded by a description of the soils and their treatment.

The mean amounts of all the ingredients determined for each of these soils are given in the next table, where they are expressed as the mean sums for the 4 feet in depth.

Mean amounts of salts recovered from the surface 4 feet of three soil types, April to September, 1902.

[In parts per 4 million of dry soil, being sums of the parts per million in the 1st, 2d, 3d, and 4th feet.]

Soil.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_3.	Total.
Selma silt loam	78.97	26.05	160.42	46.75	73.86	19.53	405.58
Norfolk sandy soil	50.65	24.02	103.51	32.87	44.47	17.50	273.02
Goldsboro compact sandy loam	17.85	22.77	72.99	38.89	59.34	11.28	223.12

These are 3 very heavy soils, whose mean weights for the surface 4 feet are nearly identical and very close to an even 4,400,000 pounds per acre-foot for the dry soil.

At the time these studies were made only the acid radicals were determined, but in 1903 the 3 bases—potash, lime, and magnesia—were also determined in 2 of these soils, and were found to constitute 55 per cent of the negative radicals. On this basis, the dry weights of the soil, and the data in the table above, the total water-soluble salts recovered with water alone, treating the fresh field samples but three minutes, are as follows:

Water-soluble salts recovered from three soils—1902.

[In pounds per acre.]

Salts.	Selma silt loam.	Norfolk sandy soil.	Goldsboro compact sandy loam.
Observed negative radicals in 4 feet	1,763	1,170	1,021
Computed K, Ca, and Mg in 4 feet	970	644	562
Total pounds per acre in 4 feet	2,733	1,814	1,583
Relative amounts on basis of 100 for the largest	100.00	66.37	57.92

From this table it appears that enough determined water-soluble salts were recovered from these soils to equal 2,733, 1,814, and 1,583 pounds per acre in the surface 4 feet, the poorest soil yielding about 58 and the intermediate one 66 per cent as much as the Selma silt loam, which is acknowledged by practical men to be the strongest of the 3 soils.

It must be said, however, regarding these 3 soils that the observed differences in the productive capacities of the fields studied are unquestionably partly due to differences of treatment by their managers. Whether or not the observed differences in the water-soluble salts were due in part to differences in management was a part of the purpose of these studies to determine.

YIELDS OF COTTON AND AMOUNTS OF WATER-SOLUBLE SALTS RECOVERED BY COTTON PLANTS.

As cotton was grown on but 2 of the fields whose soluble salt contents were followed through the season, the yields can be specifically compared upon but 2 of the soils. On September 25, through a collection of plants from the areas sampled during the season, it was determined that the Norfolk sandy soil had produced a field weight of plants (entire plants above ground) equal to 3,320 pounds per acre, and the Goldsboro compact sandy loam a weight of 1,710 pounds.

The amounts of acid radicals found in the cotton plants growing on the 2 soils are given in the next table, as the mean results of the several determinations during the growing season.

Mean water-soluble salts in cotton plants grown on 2 soils—1902.

[In parts per million of dry plant.]

Soil.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_3.
Norfolk sandy soil	4,429	4,063	11,813	1,015	9,559	558
Goldsboro compact sandy loam	949	3,606	4,328	968	22,844	594
Difference	3,480	457	7,485	47	−13,285	−36

Notwithstanding the fact that a smaller crop grew upon the Goldsboro compact sandy loam, where the soluble salts have been shown to have been less, except in the case of chlorine, it will be seen from the table that the ratio of salts to the dry matter in the plants is also less. To obtain the relative amounts of salts recovered from the 2 soils by the 2 crops it is necessary to take into account the differences in yield. The ratios are as follows:

Recovered salts, 1583 to 1844 = 1 to 1.17.
Weights of plants, 1710 to 3320 = 1 to 1.94.

The relative amounts of the different ingredients actually recovered from these soils by the cotton plants will, therefore, be more cor-

rectly expressed by multiplying the parts per million recovered from the plants on the Norfolk sandy soil by 1.94 and dividing the results by the parts per million in the plants from the other soil. When this is done the values obtained are as below:

Ratio of water-soluble salts recovered by cotton plants from two soil types—1902.

Soil.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_3.
Norfolk sandy soil	9.05	2.18	5.29	2.03	0.85	1.82
Goldsboro compact sandy loam	1.00	1.00	1.00	1.00	1.00	1.00

By the method of washing the soils, carried through the season, and by examining the plant sap of the crops growing upon the soils, it has been shown that the recoverable water-soluble salts have been materially larger in the Norfolk sandy soil, where the yields have also been larger. It is worthy of note here that, in the case of the chlorine, both methods of approaching the problem agree in showing more chlorides recoverable from the Goldsboro compact sandy loam, although with other salts the reverse relation was found.

Water-Soluble Salts Recovered from Twenty Cotton Fields on Each of Three Soil Types.

On July 21, 1902, the field party was divided into 3 sections and each, with a team, collected soil samples and plant samples from 20 different cotton fields on each of the 3 soil types, Selma silt loam, Norfolk sandy soil, and Goldsboro compact sandy loam. The distance covered by each party was from 15 to 25 miles, the localities for collecting having been previously determined and designated upon soil maps. The fields were sampled between the rows, to partly avoid the effect of fertilizers applied in the drills, and to a depth of 4 feet. One core was taken from each field, care being exercised to select typical average conditions for the places of sampling. The 20 cores from each depth were put together, thus constituting a single 20-core composite in the 3 cases for each of the 4 depths.

A typical and average plant was also taken from each locality, and these were worked into composite samples and examined for water-soluble salts in the sap of the plants. The dry weights of the plants were determined to serve as a basis for comparative yields on the 3 soil types. It should be observed that the fields visited for these composite samples represent, on the average, less well-cared for farms than those just referred to, which lie near the city, where both mineral fertilizers and stable manure are more extensively and generally used. In the table which follows are given the results obtained from this series of observations:

Water-soluble salts in the surface 4 feet of 3 soil types, taken under cotton July 21 from 20 different localities, and in cotton plants growing thereon—1902.

[Salts in parts per million of dry weight.]

Soil types.	Moisture.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_3.	Total.
SURFACE FOOT.								
	Per cent.							
Selma silt loam	8.58	12.12	8.96	13.70	4.01	15.54	2.16	56.49
Norfolk sandy soil	4.17	6.48	5.67	14.00	5.08	8.84	1.37	41.44
Goldsboro compact sandy loam	8.34	11.13	7.05	12.60	4.01	10.87	.54	46.20
SECOND FOOT.								
Selma silt loam	14.03	5.34	9.10	11.10	4.23	18.02	3.99	51.78
Norfolk sandy soil	8.81	4.40	6.70	6.32	4.02	14.00	2.52	37.96
Goldsboro compact sandy loam	10.38	6.12	5.30	9.06	2.73	15.85	2.57	41.63
THIRD FOOT.								
Selma silt loam	16.28	5.28	8.90	6.84	2.89	20.19	6.62	50.72
Norfolk sandy soil	11.73	3.63	5.40	8.70	4.14	14.43	5.95	42.25
Goldsboro compact sandy loam	13.13	4.11	5.50	5.55	2.82	16.38	4.91	39.27
FOURTH FOOT.								
Selma silt loam	16.96	4.79	8.55	6.31	2.19	22.86	6.07	50.77
Norfolk sandy soil	12.74	9.04	5.44	12.09	1.40	22.70	5.64	56.31
Goldsboro compact sandy loam	15.07	4.58	4.79	4.50	4.29	14.98	5.77	38.91
COTTON PLANTS.								
On Selma silt loam	338.7	412	3,425	10,380	2,759	12,652	2,788	32,416
On Norfolk sandy soil	340.5	1,799	3,355	10,674	3,003	16,903	2,674	38,409
On Goldsboro compact sandy loam	300.0	529	2,567	8,991	2,821	15,451	2,803	33,160

The total salts recovered from the surface 4 feet of the 3 soils are given in the next table:

Soluble salts recovered from surface 4 feet of three soil types—1902.

[In parts per million of dry soil.]

Depth.	Selma silt loam.	Norfolk sandy soil.	Goldsboro compact sandy loam.
Surface foot	56.49	41.44	46.20
Second foot	51.78	37.96	41.63
Third foot	50.72	42.25	39.27
Fourth foot	50.77	56.31	38.91
Sums [a]	209.76	177.96	166.01

[a] Parts per 4 million.

The figures representing the yields of dry matter at the time of collecting the samples, as indicated by the 20 cotton plants collected, were: Selma silt loam, 39.78; Norfolk sandy soil, 27.67, and Goldsboro com-

pact sandy loam, 28.69. If, for convenience in comparing, we let 1 represent the yield of the Goldsboro compact sandy loam, the yield from the Norfolk sandy soil would be represented by 0.96, and the yield from the Selma silt loam by 1.38.

The total salts computed from the mean dry weight of the surface 4 feet (p. 41) are next given, together with the relative amounts of the total salts recovered from the soils, as indicated by the strength of the plant sap and the relative amounts of dry matter on the ground at the time.

Total soluble salts recovered from three soil types—1902.

[Pounds per acre in the surface 4 feet.]

	Selma silt loam.	Norfolk sandy soil.	Goldsboro compact sandy loam.
Computed bases	505	427	415
Acid radicals	919	776	755
Total salts	1,424	1,203	1,170

If again, for convenience in making comparisons, we let 1 represent the amount of soluble salts recovered by washing from the poorest soil—the Goldsboro compact sandy loam—and 1 represent the salts recovered by the plants from the same soil, reducing the values for the other two soils to correspond, and compare with these the figures given above as representing relative yields from the same soils, we have the following table:

Relative amounts of soluble salts recovered by washing, and by plants from three soils, and relative yields from the same soils—1902.

	Selma silt loam.	Norfolk sandy soil.	Goldsboro compact sandy loam.
Soluble salts recovered:			
By washing	1.22	1.03	1
By plants	1.35	1.11	1
Yields	1.38	.96	1

Here only the Selma silt loam shows any measurable difference in the amount of water-soluble salts recoverable from the soil, and it is the only one upon which the yield is measurably different. It is to be noted that the samples are measurably poorer in dissolved salts than those from the fields investigated nearer the city, which results partly from the samples having been taken between rather than under the rows.

In a third comparison, made in July on these 3 soils under cotton, the relative yields of dry matter, as reflected in the weights of sets of

typical plants growing directly over where the soil samples were taken, were found to be:

Relative mean dry weights of plants from 3 soils—1902.

Selma silt loam.	Norfolk sandy soil.	Goldsboro compact sandy loam.
40.27	33.66	14.61

The total acid radicals recovered from the surface 4 feet of these 3 soils and from the plants growing upon them are given in the next table:

Total water-soluble salts in soils and plants—1902.

[In parts per million of dry weight.]

	Selma silt loam.	Norfolk sandy soil.	Goldsboro compact sandy loam.
Average for the 4 feet..	85.99	67.66	57.38
From plants	32,843	24,031	36,894

Employing the mean weights per cubic foot of soil already used (see p. 41) to compute the amounts of soluble salts in pounds per acre, we get the results which appear in the next table, where the bases also have been computed as was done on p. 42.

Total soluble salts recovered from surface 4 feet of three soils—1902.

[In pounds per acre.]

	Selma silt loam.	Norfolk sandy soil.	Goldsboro compact sandy loam.
Acid radicals recovered from soil	1,506	1,179	1,040
Potash, lime, and magnesia, computed	828	648	572
Total salts	2,334	1,827	1,612

Relative size of the crop yields and relative amounts of salts recovered from the three soils, assuming the data for the Goldsboro compact sandy loam to be represented by 1—1902.

	Goldsboro compact sandy loam.	Norfolk sandy soil.	Selma silt loam.
Relative size of yields	1	237	275
Relative amounts of salts recovered:			
By washing soil	1	113	145
By plants	1	154	242

Here the differences in the crop are well marked and the differences in recoverable salts are also strong and somewhat in correspondence with the yields.

WATER-SOLUBLE SALTS RECOVERED FROM SOILS OF DIFFERENT PORTIONS OF THE SAME FIELD WHERE CROPS ARE LARGE AND SMALL.

IN FIELD OF PEAS.

In a field of peas planted in January on the Norfolk sandy soil notable differences in the size and vigor of the plants were observed in different portions, and observations were made to ascertain if measurable differences existed in the amounts of salts which could be recovered from the soils under the two crop conditions. The field had been planted in rows 3.5 feet apart, under which guano had been drilled at the rate of 500 pounds per acre and with it stable manure at the rate of 50 bushels per acre. (The guano was guaranteed to contain 5 per cent potash, 5 per cent ammonia, and 8 per cent phosphoric acid.) The samples were collected on May 5 and 6, nearly four months after the fertilizers had been applied. Samples were collected (both under and between the rows) where the plants were evidently doing best and where they were less vigorous, in 1-foot sections to a depth of 4 feet. Samples of soil and of plants were collected from 4 sets of different localities in the field where the crop showed marked differences in color, size, and vigor of plants, and the results appear in the next table:

Water-soluble salts recovered from soils under good and poor crops of growing peas and from the plants—1902.

[Salts in parts per million of dry weight.]

	Moisture.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_3.	Sum.
FIRST FOOT UNDER ROW.								
	Per cent.							
Under good peas	4.07	8.16	11.34	48.88	12.97	18.41	1.36	101.12
Under poor peas	6.04	4.76	8.01	32.85	9.67	18.87	2.09	76.25
Difference	−1.97	3.40	3.33	16.03	3.30	−.46	−.73	24.87
SECOND FOOT UNDER ROW.								
Under good peas	5.71	4.70	7.91	31.42	19.75	22.55	3.13	89.46
Under poor peas	7.29	3.28	5.16	22.87	17.89	19.13	3.19	71.52
Difference	−1.58	1.42	2.75	8.55	1.86	3.42	−.06	17.94
THIRD FOOT UNDER ROW.								
Under good peas	10.87	4.68	5.37	34.58	20.87	11.92	5.16	82.58
Under poor peas	12.49	3.25	3.88	30.66	14.47	16.18	5.62	74.06
Difference	−1.62	1.43	1.49	3.92	6.40	−4.26	−.46	8.52
FOURTH FOOT UNDER ROW.								
Under good peas	10.38	4.34	5.30	34.13	20.51	19.78	4.39	88.45
Under poor peas	10.87	3.87	3.83	33.91	11.02	11.93	5.53	70.03
Difference	−.49	.53	1.47	.22	9.49	7.85	−1.14	18.42

Water-soluble salts recovered from soils under good and poor crops of growing peas and from the plants—1902—Continued.

PLANTS.

	Moisture.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_3.	Sum.
	Per cent.							
From good peas	452.5	398.2	3,324	Not determined.	3,581	4,040	1,083	12,426
From poor peas	354.5	260.1	2,666		793	3,881	526	8.126
Difference	98.0	138.1	658		2,788	159	557	4,300

A careful determination of the relative yields (total green weight) when the soils were collected gave the following values at the time the crop was nearing the stage for picking for market: Good peas, 7,412 pounds per acre; poor peas, 2,232 pounds per acre. The owner realized 80 baskets of peas per acre from the field, and these sold for $0.50 to $1.50 per basket.

It will be seen that measurable differences have been observed in the amounts of water-soluble salts recovered from these areas by using distilled water in all 4 feet, and that, with the exception of chlorine and silica, there are no instances where more salts are not found under the stronger plants, notwithstanding the fact that they were drawing more heavily upon the soil, as proved by the soil moisture being less at the time under the largest plants.

In the next table are given the total salts and moisture for the 4 feet under the two conditions and computed on a dry weight of soil equal to 4,000,000 pounds per acre-foot, which is materially less than the true value.

Total water-soluble salts per acre recovered from surface 4 feet of Norfolk sandy soil under good and poor peas—1902.

Soil under—	Soil moisture.	Observed acids.	Computed bases.	Total salts.
	Tons.	*Pounds.*	*Pounds.*	*Pounds.*
Good peas	620.6	1,446	795	2,241
Poor peas	733.8	1,167	642	1,809
Difference	113.2	279	153	432

The crop yields stand in the ratio of 3.22 to 1. Using this ratio and the observed salts recovered from the plant sap to compute the relative amounts of salts recovered from the soil by the plants, we have the following:

Ratios of salts recovered from the soil, of yields, and of salts in plant sap—1902.

	Under good peas.	Under poor peas.
Of salts recovered from soil—		
By washing in distilled water	1.26	1
By the plants	5.07	1
Of yields	3.32	1
Of salts in plant sap	1.53	1

In Field of Corn.

It is a common practice in the South to build in fields during the late fall and winter compost heaps of various materials, and to spread them over the fields in the later winter and early spring. In a cornfield on the Selma silt loam this had been done, and there was such a strong contrast between the large plants growing where the compost had lain during perhaps sixty days and the smaller plants growing elsewhere in the field that the water-soluble salt conditions were determined with the results which follow:

Water-soluble salts recovered from soils under large and small corn and from the plants—1902.

[Salts in parts per million of dry weight.]

Source.	Moisture.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_3.	Sum.
FROM SURFACE FOOT OF SOIL.								
	Per cent.							
Under large corn	10.74	92.00	24.53	54.90	6.83	15.90	2.94	197.10
Under small corn	10.13	6.52	10.59	11.70	4.73	Trace.	1.83	35.37
Difference	.61	85.48	13.94	43.20	2.10	15.90	1.11	161.73
FROM SECOND FOOT OF SOIL.								
Under large corn	14.29	43.40	15.04	50.27	5.68	9.90	4.19	128.48
Under small corn	15.87	2.32	7.20	26.11	3.60	8.38	5.82	53.43
Difference	− 1.58	41.08	7.84	24.16	2.08	1.52	−1.63	75.05
FROM THIRD FOOT OF SOIL.								
Under large corn	16.69	18.00	4.88	34.33	Trace.	21.10	7.43	85.74
Under small corn	16.14	1.69	4.04	13.91	5.06	5.88	7.78	38.36
Difference	.55	16.31	.84	20.42	−5.06	15.22	−.35	47.38
FROM FOURTH FOOT OF SOIL.								
Under large corn	16.69	4.23	6.50	25.10	6.54	8.46	6.65	57.48
Under small corn	9.89	2.77	5.29	8.53	4.74	7.87	6.93	36.13
Difference	6.80	1.46	1.21	16.57	1.80	.59	−.28	21.35
FROM CORN PLANTS.								
From large corn	900	28,687	8,620	2,419	1,108	4,399	1,457	36,690
From small corn	669	1,198	4,888	1,852	793	3,764	1,266	13,761
Difference	231	27,489	3,732	567	315	635	191	22,929

In this case there was a very large difference in the growth of the plants, the ratio of dry matter in the two cases being as 9 to 1, and it will be seen from the table that there is a very measurable difference between the recoverable amounts of water-soluble salts.

We bring together in this case, also, the total salts recoverable from the 4 feet by the 3-minute washing in distilled water.

Total water-soluble salts recovered from the surface 4 feet of Selma silt loam under large and small corn—1902.

[In pounds per acre.]

Source.	Total observed acid radicals.	Computed potash, lime, and magnesia.	Total salts.
Under large corn	1,875	1,031	2,906
Under small corn	657	361	1,018
Difference	1,218	670	1,088

Expressing these results in the form of ratios, as has been done before, we have the following:

Ratios of salts recovered from the soil, of crop yields, and of salts in plant sap—1902.

	Under large corn.	Under small corn.
Of salts recovered from soils—		
By washing in distilled water	2.86	1
By the plants	23.99	1
Of yields	9.00	1
Of salts in plant sap	2.67	1

The ratio of salts in the plant sap, it will be seen, is close to that of the salts recovered from the two soils by washing.

In Fields of Beans.

Four fields of beans growing upon the Goldsboro compact sandy loam, 2 of them directly adjacent and the other 2 separated by distances less than 800 feet, with the 2 adjacent fields between the 2 most distant, showed such evident differences in the growth of the crops while the character of the soil was the same, so far as could be judged from field conditions, that these were examined for water-soluble salts by washing in distilled water, and the observed differences follow:

Water-soluble salts recovered from soils under large and medium beans, and from plants—1902.

[Salts in parts per million of dry weight.]

Soil.	Moisture.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_3.	Sum.
FROM SURFACE FOOT UNDER ROW.								
	Per cent.							
Under large beans	4.68	22.32	8.52	207.94	6.08	14.87	4.52	264.25
Under medium beans	7.84	8.66	5.02	69.37	Trace.	13.62	2.15	98.82
Difference	−3.16	13.66	3.50	138.57	6.08	1.25	2.37	165.43
FROM SECOND FOOT UNDER ROW.								
Under large beans	10.39	5.78	6.06	49.80	4.73	13.16	7.23	86.76
Under medium beans	12.69	2.89	4.27	30.38	1.73	4.86	3.38	47.51
Difference	−2.30	2.89	1.79	19.42	3.00	8.30	3.85	39.25

Water-soluble salts recovered from soils under large and medium beans, and from plants—1902—Continued.

FROM THIRD FOOT UNDER ROW.

Soil.	Moisture.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl,	SiO_3.	Sum.
	Per cent.							
Under large beans	15.70	6.53	5.21	46.64	9.29	10.85	8.57	87.09
Under medium beans	14.95	4.83	2.39	7.87	Trace.	10.40	4.03	29.52
Difference	.75	1.70	2.82	38.77	9.29	.45	4.54	57.57

FROM FOURTH FOOT UNDER ROW.

Soil.	Moisture.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl,	SiO_3.	Sum.
Under large beans	18.84	15.09	4.58	19.89	6.70	15.13	8.39	69.78
Under medium beans	16.35	9.36	2.02	1.14	Trace.	12.22	5.05	29.79
Difference	2.49	5.73	2.56	18.75	6.70	2.91	3.34	39.99

FROM BEAN PLANTS.

Soil.	Moisture.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl,	SiO_3.	Sum.
From large plants	514.1	752	1,998	1,839	1,890	17,465	499	24,443
From medium plants	640.2	860	470	1,851	657	26,595	1,644	32,071
Difference	−126.1	−108	1,528	−12	1,233	−9,130	−1,115	−7,628

The relative yields in these 4 fields were not accurately determined. but it was my judgment and that of the field men when on the ground that the 2 fields of larger beans would give yields 2 or 3 times as large as those on the other 2 fields; hence the ratio was estimated at 2.50 to 1. One of the fields of larger beans gave a yield of 160.65 baskets per acre.

In the following table are shown the amounts of salts recovered from the two groups of field soils:

Total water-soluble salts per acre recovered from surface 4 feet of soils under large and medium beans—1902.

Soil.	Total observed acid radicals.	Computed potash, lime, and magnesia.	Total salts.
	Pounds.	*Pounds.*	*Pounds.*
Under large beans	2,032	1,118	3,150
Under medium beans	824	442	1,266
Difference	1,208	676	1,884

When these results are expressed in the form of ratios, we have—

Ratios of salts recovered from soils, of yields, and of salts in plant sap—1902.

	Under large beans.	Under medium beans.
Of salts recovered from soils:		
By washing in distilled water	2.46	1
By the plants	1.91	1
Of yields	2.50	1
Of salts in plant sap	.76	1

It will be observed from the table (p. 96) that the smaller plants have carried smaller proportions of the recovered salts than the larger plants have, when measured in parts per million of dry matter. This relation, however, may be misleading unless it is explained that the larger plants, on account of having been better fed, and partly also on account of having been planted a little earlier, had more nearly developed their maximum amounts of dry matter, and hence the water-soluble salts appear smaller, relatively, on this account.

In Field of Cotton.

In a cotton field on the Selma silt loam there was a locality where on July 17, upon immediately contiguous areas, the cotton plants, though planted on the same date and treated in every way alike, had attained very different sizes and showed widely different degrees of vigor. It was decided to examine the soil under these areas and samples were collected and the salts determined. The areas are designated A, C, and B. At that time A bore the largest and best plants, while B bore the smallest and, at the time, very poor plants. The mean dry weights of average-sized individual plants over the respective areas were, in grams, on July 17: A, 85.64; C, 34.46; B, 0.99. As the season advanced the plants on the B area came to be the largest, while the A plants were the smallest but matured earliest. Samples of soil were taken again August 29 and the results of the several determinations appear in the next table:

Water-soluble salts recovered from plants and from the surface 4 feet of soils where cotton was "large," "medium," and "small" on July 17, but where the sizes became reversed before August 29—1902.

[Moisture in per cent of dry weight; water-soluble salts in parts per million of dry matter.]

	Depth.	July 17.			August 29.	
		A, large.	C, medium.	B, small.	A, large.	B, very large.
Moisture in—						
Soils	First foot	7.53	19.91	12.61	7.76	18.77
	Second foot	12.37	21.21	21.65	11.98	23.61
	Third foot	14.95	23.31	22.70	14.95	23.45
	Fourth foot	10.13	21.06	18.62	9.65	21.65
Plants		367	418	533	230	326
Nitrates as NO_3 in—						
Soils	First foot	34.70	59.00	71.10	2.89	5.43
	Second foot	3.56	5.40	4.02	3.25	5.88
	Third foot	2.91	5.10	4.02	.40	6.79
	Fourth foot	2.17	3.66	2.93	5.14	6.25
Plants		6,112	3,192	10,461	499	243
Phosphates as HPO_4 in—						
Soils	First foot	7.37	7.95	7.77	2.95	3.32
	Second foot	5.83	6.79	5.98	.77	.86
	Third foot	6.38	6.50	6.88	1.60	.86
	Fourth foot	5.30	5.90	6.65	1.51	.85
Plants		2,341	2,605	3,302	3.307	4,149

Water-soluble salts recovered from plants and from the surface 4 feet of soils where cotton was "large," "medium," and "small" on July 17, and where the sizes became reversed before August 29—1902—Continued.

	Depth.	July 17.			August 29.	
		A, large.	C, medium.	B, small.	A, large.	B, very large.
Sulphates as SO_4 in—						
Soils	First foot	104.00	111.04	47.00	37.40	58.60
	Second foot	22.40	11.90	11.44	19.70	17.11
	Third foot	26.43	1.83	1.82	3.37	2.44
	Fourth foot	2.67	1.80	1.75	1.60	1.21
Plants		5,156	8,320	16,180	6,454	9,745
Bicarbonates as HCO_3 in—						
Soils	First foot	3.96	6.75	7.67	7.92	2.98
	Second foot	2.78	3.04	6.12	5.55	4.66
	Third foot	4.29	3.10	5.43	2.86	3.10
	Fourth foot	6.78	2.28	5.95	2.71	3.06
Plants		2,293	4,738	4,479	1,367	1,486
Chlorides as Cl in—						
Soils	First foot	12.28	31.32	19.39	9.23	6.92
	Second foot	16.16	19.50	24.79	8.08	9.02
	Third foot	25.00	25.20	30.44	8.32	7.21
	Fourth foot	18.89	19.39	25.40	6.30	7.11
Plants		6,659	9,103	10,600	4,895	5,437
Silicates as SiO_3 in—						
Soils	First foot	1.42	5.04	2.63	4.28	9.58
	Second foot	3.18	6.13	8.62	7.45	11.28
	Third foot	6.54	12.29	9.12	13.83	12.94
	Fourth foot	4.02	13.87	10.76	10.90	14.37
Plants		1,010	522	1,456	690	409
Sums of salts in—						
Soils		[a]329.02	[a]374.78	[a]327.68	[a]168.01	[a]231.83
Plants		23,571	28,480	46,478	17,212	21,469

[a] Parts per 4 million.

It will be seen from the foregoing table that on July 17 the recovered salts were, in the grand total, practically the same under the largest and smallest plants. It is also seen that the differences in size of plants at that time were not apparently related in any way to the moisture contents of the soil, for while the soil under the B plants was notably wetter than that under the A plants, it can not be said that the soil was too wet in one case, because the C plants, which are intermediate between the other two, were growing upon the wettest soil. There was also, at the time, in the C soil, on the whole, more recoverable water-soluble salts. At the end of August, however, not only had the relative sizes of the cotton plants under the A and B conditions changed, but the larger plants were at this time associated with the larger amount of water-soluble salts recovered from the soil.

It is true, if it is admitted that the salts recovered from the soils on July 17 were in solution in the soil moisture at the time, that the roots of the A plants were bathed in a stronger solution than the roots of the B plants, but observations showed that the plant sap was weaker in the A plants at this time, judged by the salts recovered by the methods used. The strength of the plant sap on the two dates, for the A and B plants, are given below:

Water-soluble salts in sap of cotton plants of different sizes on two dates—1902.

[In parts per million of plant sap.]

Salts.	July 17.		August 29.	
	A, large.	B, small.	A, large.	B, very large.
NO_3	1,665	1,962	217	75
HPO_4	637	620	1,437	1,275
SO_4	1,404	3,043	2,850	2,443
HCO_3	624	841	594	456
Cl	1,812	1,989	2,127	1,670
SiO_3	275	273	300	126
Total	6,417	8,728	7,525	6,045

The total water-soluble salts recovered from these soils on the basis of 4,000,000 pounds as the dry weight of an acre-foot are given in the next table.

Total water-soluble salts per acre recovered from the surface 4 feet of Selma silt loam under cotton plants of different sizes—1902.

Salts.	July 17.			August 29.	
	A, large.	C, medium.	B, small.	A, large.	B, very large.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Acid radicals	1,316	1,499	1,311	672	927
Computed potash, lime, and magnesia	724	824	721	370	510
Total	2,040	2,323	2,032	1,042	1,437

UNDER FERTILIZED AND UNFERTILIZED COTTON.

In a cotton field on the Goldsboro compact sandy loam, at our request, the proprietor, at the time of planting, missed drilling into 3 rows any guano. The date of planting was April 26. On June 24 samples of soil and of plants were collected from the middle one of the 3 unfertilized rows of cotton and from each of the second fertilized rows on either side of the 3 unfertilized rows. The total salts recovered on this date from the soils and plants are given in the next table.

Water-soluble salts recovered June 24 from soils and cotton plants where fertilizers had and had not been applied—1902.

[Moisture in per cent of dry matter; salts in parts per million of dry matter.]

	From soils.		From plants.	
	Fertilized.	Unfertilized.	Fertilized.	Unfertilized.
Moisture	13.23	14.19	452.5	426.3
NO_3	5.03	9.21	4,309	4,217
HPO_4	6.06	4.53	4,079	4,302
SO_4	23.03	18.23	17,128	11,080
HCO_3	5.97	5.53	680	741
Cl	14.45	8.74	7,447	9,830
SiO_3	1.42	1.73	86	82
Sums	55.96	47.97	32,729	30,252

Using 4,000,000 pounds as the weight of an acre-foot the total salts recovered from the two conditions of treatment of soil stands as follows:

Total salts per acre recovered from surface 4 feet of same soil in two conditions—1902.

	Fertilized.	Unfertilized.
	Pounds.	*Pounds.*
Observed acid radicals	895	768
Computed potash, lime, and magnesia	492	422
Total in surface 4 feet per acre	1,387	1,190

The relative yields of dry matter on the ground in the cotton plants June 24 were as 4.43 to 1. On September 29 the ratio stood 1.57 to 1, the fertilized plants being largest in each case; and the total salts recovered by washing stand in the ratio of 1.17 to 1; while those recovered by the plants, according to the data for June 24, were in the ratio of 4.79 to 1.

IN FIELDS OF COTTON ON THE NORFOLK SAND, OR THE SANDHILL TYPE OF SOIL.

On the farm of Mr. U. G. Moore, lying just outside the area covered by the soil map of the Goldsboro sheet, where the soil probably belongs to the Sandhill type, but possibly would be mapped as Norfolk sand, there were 3 exceptionally good fields of cotton, and adjacent to these there were 2 others not so good. These 5 fields were examined with a view to ascertaining whether or not there were here measurable differences in the amounts of recovered water-soluble salts and whether they were related to yields.

Mr. U. G. Moore owns a small dairy and uses his stable manure in connection with fertilizers in keeping up his fields, and it was on the fields so treated that the largest cotton was found. Plate I shows the relative sizes of the cotton on the 3 fields of large plants in question and of the plants on the other 2 fields of the Sandhill type. With these is an average plant from the Goldsboro compact sandy loam, from which came the data of the table appearing on page 40. The illustration also shows an essential difference in the development of the root systems, the cotton plants putting their roots much more deeply in the soil of the Sandhill type than they did in that of the Goldsboro compact sandy loam.

In the following table are given the mean amounts of salts recovered from the surface 4 feet of the fields in question, under both large and small cotton plants:

Water-soluble salts recovered from 4 feet of soils where cotton was large and small—1902.

[In parts per 4 million of dry soil, being sums of the parts per million in the 1st, 2d, 3d, and 4th feet.]

Soils.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_3.
Under large cotton	15.21	15.15	55.09	25.87	31.25	11.13
Under small cotton	12.73	13.99	34.78	20.19	43.26	7.56
Difference	2.48	1.16	20.31	5.68	−12.01	3.57

TYPICAL COTTON PLANTS FROM THREE FIELDS.

Large plant (at right) from field of large plants, and small plant (on left) from field of small plants on Sandhill type of soil; average plant (in center) from field on Goldsboro compact sandy loam.

Using 4,000,000 pounds as the weight of an acre-foot, the total salts recovered from the two conditions of treatment of soil stand:

Total salts per acre recovered from surface 4 feet of two soils—1902.

	Under large plants.	Under small plants.
	Pounds.	*Pounds.*
Observed acid radicals	615	530
Computed potash, lime, and magnesia	338	292
Total in surface 4 feet per acre	953	822

The mean yield of lint from the 3 fields of large cotton was given by Mr. U. G. Moore as 522 pounds per acre, the separate yields being 600, 500, and 465 pounds per acre. The yield on the other 2 fields—that of Mr. Geo. C. Moore and Mr. Hood—was 450 pounds in each case. It is clear, therefore, both from the illustration and from the crop returns, that in the 3 cases where stable manure was used on the soil, and where the soluble salts recovered were largest (with the exception of the chlorides), the yields have been greatest.

WATER-SOLUBLE SALTS RECOVERED FROM SOILS IN A SERIES OF ISOLATED CASES.

Observations were also made in a number of isolated cases upon soils where it was seen that the crops were widely different in growth and vigor. Samples of both the soils and plants were collected from each locality and the relative amounts of dry matter in the crops, over the ground sampled, were measured by ascertaining the total dry weights of the plants growing upon the particular spots where the soil cores were procured.

Under Cotton Plants of Unequal Size.

Across one end of the cotton field on the Goldsboro compact sandy loam, where the soluble salts were followed through the season, an old surface ditch had been filled some eight years prior to the observations here recorded. Over this ditch the cotton plants were very much stronger than anywhere else in the field, and the position of the old ditch was sharply indicated by the marked contrast of the cotton plants in the rows where they crossed it. On July 30, the day a set of samples was taken in the general field, samples were also taken at one place under these large plants. At the same time the soil was excavated across 2 cotton rows and the roots were exposed by washing the soil away with water. Contrary to what had been found true for the field generally, the roots of the cotton plants penetrated to the full depth of 4 feet, while ordinarily no roots were observed below 2 feet and nearly all were above 18 inches in this field.

In the next table are given the differences in the physical conditions of the soil in the two localities.

Physical conditions of two soils bearing large and small cotton plants—1902.

Depth.	Dry weight of soil per cubic foot.		Moisture computed as per cent of the dry weight of—			
			Soil under—		Plants.	
	Under large plants.	Under small plants.	Large plants.	Small plants.	Large.	Small.
	Pounds.	*Pounds.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
First foot	90.94	97.00	5.15	6.72	371.7	418.2
Second foot	87.73	106.00	5.82	10.50		
Third foot	96.76	106.80	11.11	14.03		
Fourth foot	111.00	106.60	12.23	15.34		

The water-soluble salts recovered are given in the next table.

Soluble salts recovered from two soils bearing small and large cotton plants, and from the plants—1902.

[In parts per million of dry matter.]

WHERE PLANTS ARE LARGE.

	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_3.
Soil:						
First foot	13.20	10.10	13.20	15.45	8.97	2.77
Second foot	10.40	7.95	8.36	11.76	9.03	4.18
Third foot	19.02	5.37	10.26	8.24	7.98	7.02
Fourth foot	9.90	6.98	27.40	6.26	14.54	2.61
Sum [a]	52.52	30.40	59.02	41.71	40.52	16.58
Plant	1,469	4,953	11,536	2,794	5,475	273

WHERE PLANTS ARE SMALL.

	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_3.
Soil:						
First foot	4.58	7.65	22.15	15.73	28.88	2.29
Second foot	2.59	7.20	21.50	12.28	14.26	1.65
Third foot	1.96	7.12	21.21	8.50	11.56	1.16
Fourth foot	3.45	7.60	10.18	7.90	15.04	1.74
Sum [a]	10.58	29.57	75.04	44.41	69.74	6.84
Plant	287	3,419	17,596	1,986	15,773	1,024

[a] Parts per 4 million.

The mean dry weights of single plants growing in these two places at the time were 126.4 grams and 40.12 grams, or a ratio of 3.07 to 1. It will be seen from the above tables that the largest plants were on the much more open soil, so far as the surface 3 feet are concerned, and that the soil and plant contained relatively less water. There is little doubt in this case that the better physical condition which has permitted a deeper root penetration has had much, if not most, to do in determining the relatively large size of the plants growing over the old filled ditch.

It is to be observed, however, that the total nitrates recovered from the old ditch soil were five times as abundant as they were from the

soil where the plants were smaller, and, further, that there was 22 per cent more phosphoric acid recovered from the surface 2 feet. Moreover, the sap of the larger plants yielded in parts per million of the dry matter more of both of these essential ingredients, and it is to be presumed that both soil and plant would have shown more of the essential bases—lime and magnesia—if not of potash as well. Although there are more of the other ingredients determined in the soils bearing the smaller plants, there is, nevertheless, hardly 2 per cent more salts of all kinds, and the larger plants, on account of their greater size, have recovered from the soil absolutely more of every salt ingredient, retaining them still in recoverable form by the methods used, with the exception of chlorine and silica.

Under Corn Plants of Unequal Size.

There were, on July 31, 3 fields of corn where the plants had notably different degrees of vigor and size, although planted at the same time. Places in each of these were chosen for a comparative study of water-soluble salts in relation to yield, and the data obtained are incorporated in the next table, where the sums of the determinations for the 4 feet are combined. The mean dry weights of the plants growing above the sampled soil were 134, 303, and 525.86 grams, respectively. The corn in each case was just coming into full tassel.

Moisture in soil and water-soluble salts recovered from the surface 4 feet of soil in three places in cornfields and from the corn growing upon it in each place—1902.

	Soil.		
	Poorest.	Medium.	Best.
Dry weight of plant, in grams	134	303	526
Moisture in per cent of dry weight:			
Soil—First foot	4.49	16.82	13.13
Second foot	12.11	15.79	16.96
Third foot	17.79	15.67	22.85
Fourth foot	18.77	16.55	21.95
Plants	258	304	310
Water-soluble salts in parts per 4 million of dry soil:			
NO_3	10.21	4.31	17.30
HPO_4	13.69	24.77	36.33
SO_4	26.85	22.72	64.42
HCO_3	29.12	30.68	41.42
Cl	41.90	42.88	43.23
SiO_3	15.04	4.39	5.18
Total salts	136.81	129.75	207.88
Water-soluble salts in parts per million of dry weight of plants:			
NO_3	218	328	1,064
HPO_4	1,207	2,117	1,452
SO_4	1,462	2,257	1,345
HCO_3	725	960	905
Cl	1,298	816	2,074
SiO_3	182	986	257
Total salts	5,092	7,464	7,097

From the foregoing table it is seen that the water-soluble salts recovered from the soil under the poorest corn by washing with distilled water were richer in nitrates than those recovered from the soil under the medium corn: the sulphates and silica and the sum total are also a little greater. In the case of the medium and the largest yields, the recovered salts stand, in every case, largest where the corn plants were largest.

If the amounts of salts recovered by the corn plants from the soil under the three conditions, as indicated by the data, are multiplied by the dry weights of the plants, it will be seen that in every case more salts had been recovered from the soil where the plants were largest.

Under Oat Plants of Unequal Size.

In a series of observations on oat fields a specific study was made of the soil directly beneath oat plants showing markedly different sizes and degrees of vigor. Results were obtained in 6 cases, which are presented in tabular form as has been done with the corn, under the respective weights of dry matter upon a square foot of surface sampled. In one pair in this series the samples were taken from different fields, as was the case with the corn: in another pair the samples are taken from distant portions of the same field; and in the third pair the samples came from small areas in the oat field where the growth was notably stronger than from the field generally.

Water-soluble salts recovered from surface 4 feet of six soils arranged in pairs on which were growing large and small oat plants, and from the plants themselves—1902.

	First pair.		Second pair.		Third pair.	
Dry weight of plants per square foot in grams	1.99	16.15	29.96	161.72	16.76	91.95
Moisture in per cent of dry weight:						
Soil—						
First foot	10.87	16.96	9.89	24.84	13.76	22.70
Second foot	14.03	27.88	12.49	40.25	21.36	34.77
Third foot	19.62	29.37	16.28	31.58	21.80	27.55
Fourth foot	18.91	27.07	15.07	18.62	22.70	26.42
Plants	415.5	423.6	195.8	311.5	161.1	198.5
Water-soluble salts recovered from soils in parts per 4 million of dry soil:						
Nitrates (NO_3)	13.74	10.60	9.09	18.97	16.42	11.42
Phosphates (HPO_4)	18.35	24.41	19.93	33.74	35.21	41.65
Sulphates (SO_4)	14.39	30.63	40.11	242.94	43.55	72.65
Bicarbonates (HCO_3)	32.59	37.18	32.52	68.82	26.44	51.76
Chlorides (Cl)	39.44	43.34	67.69	79.91	66.87	55.27
Silicates (SiO_3)	22.52	24.35	18.21	24.40	10.45	21.85
Total	141.03	170.51	187.55	468.78	198.94	254.60
Water-soluble salts recovered from plants in parts per million of dry weight:						
Nitrates (NO_3)	397	469	474	1,005	296	359
Phosphates (HPO_4)	4,554	5,627	2,493	3,718	1,736	2,402
Sulphates (SO_4)	5,707	3,173	3,323	4,969	1,958	2,311
Bicarbonates (HCO_3)	1,359	824	1,522	1,291	844	435
Chlorides (Cl)	8,687	14,631	5,599	8,002	4,823	7,021
Silicates (SiO_3)	999	1,161	246	388	601	221
Total	21,703	25,885	13,657	19,373	10,258	12,749

From this set of data it is clear that the soil moisture in each of the 3 pairs is very appreciably higher, relatively, under the largest plants. The per cent of moisture in the plants, computed on the dry matter, is also higher where the plants are largest, and notably so except in the first pair. Pair by pair the total water-soluble salts recovered from the soil and from the plants growing upon these soils are largest in amount where the oat crop was largest.

Considering the separate ingredients determined in the soil, and omitting the NO_3, there is but one exception in the 15 pairs to larger amounts of the salts being recovered under the larger plants. Omitting the bicarbonates in the case of salts recovered from the oats themselves, there are but two exceptions in the 15 pairs to larger amounts of each ingredient having been recovered from the larger plants. The ingredients recovered as bicarbonates are notably less from the larger plants, but in the soils under them the reverse relation holds.

If we take the mean weight of an acre-foot of soil at 4,000,000 pounds and the averages of the 3 pairs of total salts as a basis for calculating the total salts in the surface 4 feet of soil under the larger and smaller oats, we have the data appearing in the next table.

Total salts in surface 4 feet of soil on which oats were grown—1902.

[In pounds per acre.]

	Under large plants.	Under small plants.
Negative radicals recovered	1,191.84	701.36
Bases, K, Ca, and Mg, computed	679.35	399.78
Total	1,871.19	1,101.14
Relative size of totals	100.00	58.84

In this table the potash, lime, and magnesia have been computed from the percentage relation referred to on page 46.

Amounts of Water-Soluble Salts in Soils under Corn and Cotton on the Edgecombe Test Farm, Penelo, N. C.

This series of observations was made on samples taken under rows of corn and cotton August 12, from plots under treatment by the North Carolina Agricultural Experiment Station. Regarding the treatment of these plats, and the yields from them, Director B. W. Kilgore writes:

Corn on plat 27 received per acre, in the drill, an application of 330.9 pounds acid phosphate, 44.4 pounds kainit, and 418.5 pounds cotton-seed meal, corresponding to formula 3 (NPK), and produced 24.5 bushels shelled corn and 2,222.5 pounds stover per acre. Plat 14 received per acre 110.3 pounds acid phosphate, 14.8 pounds kainit, and 139.5 pounds cotton-seed meal, corresponding to formula NPK, and made a yield of 27.5 bushels shelled corn and 1,880 pounds of stover.

Blank plat 14, corn fertilizer test series, received no fertilizer and produced 20.6 bushels shelled corn and 2,270 pounds stover.

The yields per acre on the remaining two plats were as follows:

Cotton after cowpeas (vines plowed in): Peas, $1\frac{1}{2}$ tons of vines; cotton, 1,800 pounds seed cotton.

Cotton after peanuts (vines removed): Peanuts, 20 bushels; cotton, 1,400 pounds seed cotton.

On the last two plats no application of fertilizer was made to peas and peanuts, but the crop of cotton following each received in the drill an application at the rate of 500 pounds per acre of a fertilizer analyzing 7 per cent phosphoric acid, 2.5 per cent ammonia, and 2 per cent potash.

The analyses of the fertilizer materials used on corn plats 14 and 27 were as follows:

	Per cent.
Acid Phosphate:	
Water-soluble phosphoric acid (P_2O_5)	13.27
Reverted phosphoric acid (P_2O_5)	2.04
Available phosphoric acid (P_2O_5)	15.31
Insoluble phosphoric acid (P_2O_5)	2.00
Total phosphoric acid (P_2O_5)	17.31
Cotton-seed meal:	
Available phosphoric acid (P_2O_5)	2.95
Insoluble phosphoric acid (P_2O_5)	.23
Total phosphoric acid (P_2O_5)	3.18
Total potash (K_2O)	1.97
Total nitrogen	6.45
Kainit:	
Total potash (K_2O)	11.84

The data obtained from a single set of samples appear in the following table:

Water-soluble salts recovered from the surface 4 feet of soils under corn and cotton on the Edgecombe Test Farm, Penelo, N. C., August 12, with data relating to soil weight, moisture, yields, etc.—1902.

	Plat 27, in corn.	Plat 14, in corn.	Plat 14, in corn.	Plat in cowpeas and cotton.	Plat in peanuts and cotton.
Fertilizers—pounds per acre	793.8	264.6	Nothing.	500	500
Yields—pounds per acre	[a] 3,645	[a] 3,420	[a] 3,423	[b] 1,800	[b] 1,400
Soil—dry weight in pounds per cubic foot:					
First foot	89.33	79.90	89.33	91.67	91.29
Second foot	98.76	90.81	82.21	93.80	91.77
Third foot	101.26	91.86	111.16	105.00	100.80
Fourth foot	97.72	103.07	102.61	111.75	112.20
Soil moisture—per cent of dry soil:					
First foot	6.72	6.50	6.72	3.41	5.04
Second foot	6.50	9.89	11.11	5.15	9.65
Third foot	16.01	18.48	16.28	14.28	16.96
Fourth foot	20.19	23.91	21.95	17.37	17.65
Water-soluble salts in parts per 4 million of dry soil:					
NO_3	12.49	12.46	15.15	15.47	10.68
HPO_4	17.85	30.76	22.65	28.76	34.83
SO_4	148.14	101.55	60.19	17.99	40.63
HCO_3	57.85	90.87	82.07	47.50	107.40
Cl	34.71	47.86	44.70	26.82	39.20
SiO_3	21.17	32.97	34.29	30.20	29.85
Total	292.21	316.47	259.05	166.74	262.59

[a] Corn and stover. [b] Seed cotton.

In this series of data there is no evident relation between either the yields or the fertilizers added and the amounts of soluble salts recovered from the soils. Moreover, there was little difference in the amounts of corn produced, notwithstanding there had been a considerable difference in the amounts of fertilizers applied. It should be emphasized here, however, that a single set of samples of soil can not be expected to represent the conditions of fields of any considerable area, such as these were, unless the samples are made up of a large number of cores taken from well-distributed places. This set of data is given here partly to illustrate the point made, but also because it is a set which signally fails to show any differences such as we have been presenting. It is not impossible, perhaps, that the drought conditions which prevailed during the season when these trials were made may have caused the failure of the addition of fertilizers to be reflected in the yields. The soils were very dry and hard at the time the samples were taken.

There have now been brought together all the data collected during 1902 which are comparable and suited to a study of the relation of yields to the recovered water-soluble salts in soils. The weight of evidence goes to show that in general, where the yields have been notably different, so have the water-soluble salts recovered by single 3-minute washings been measurably different. So, too, have the amounts of water-soluble salts still remaining in recoverable form in plant tissues been found larger in plants where the yields have been largest.

RELATION OF THE AMOUNTS OF WATER-SOLUBLE SALTS RECOVERED FROM EIGHT SOIL TYPES TO YIELDS OF CROPS.

It should be understood that the work done during the season of 1902 was intended to be simply of the nature of a reconnoissance and to develop and test the adaptability of methods. No rapid methods for the determination of bases comparable with those used for the negative radicals had been developed.

Selection and Treatment of Soil Types.

During the winter of 1902–3 methods for determining potash, lime, and magnesia were added to those already in use. To test these in field work and to make a more systematic investigation of the relation of yields to the recoverable water-soluble salts in soils, two soil types in each of four States were chosen for investigation. It was desired that four of the soils chosen should represent types whose natural productive powers are high, while four others should be from types of a recognized lower natural capacity.

The soils chosen were all in areas mapped by the bureau. The Selma silt loam and Norfolk sandy soil were selected at Goldsboro, N. C.; the

Norfolk sand and Sassafras sandy loam at Upper Marlboro, Md.; the Hagerstown loam and Hagerstown clay loam at Lancaster, Pa., and the Janesville loam and Miami loam at Janesville, Wis.

For the comparative study of this and other problems an area of 2 acres was chosen on each of the eight soil types and laid out in the manner indicated in the accompanying diagram, one portion of each being planted to corn and another to potatoes, while a third, between the two, was left fallow. The object of this division was to study any possible differential effects of crops on the water-soluble salts, as well as to have the yields of two crops instead of one to compare with the soluble salts recovered from the soils upon which they grew.

Arrangement of plots and subplots—1903.

POTATOES.	FALLOW.	CORN.
	No fertilizer applied.	
Five	tons of stable manure per	acre.
Ten	tons of stable manure per	acre.
Fifteen	tons of stable manure per	acre.
Three hun	dred pounds of guano[a] per	acre.
	No fertilizer applied.	
Five	tons of stable manure per	acre.
Ten	tons of stable manure per	acre.
Fifteen	tons of stable manure per	acre.
Three hun	dred pounds of guano[a] per	acre.
	No fertilizer applied.	
Five	tons of stable manure per	acre.
Ten	tons of stable manure per	acre.
Fifteen	tons of stable manure per	acre.
Three hun	dred pounds of guano[a] per	acre.
	No fertilizer applied.	
Five	tons of stable manure per	acre.
Ten	tons of stable manure per	acre.
Fifteen	tons of stable manure per	acre.
Three hun	dred pounds of guano[a] per	acre.

[a] No analysis was made of this guano, but the trade guaranty of its composftion was phosphoric acid 8 per cent, ammonia 3 per cent, and potash 2.5 per cent.

In order to insure well-contrasted differences of yield on the same soil type in each locality and to establish, if possible, differences in the amounts of water-soluble salts within each soil type, the 3 plots were divided cross wise into 5 series of subplots, which were fertilized as indicated in the accompanying diagram. It will be observed, with reference to the arrangement and number of these subplots, that the plan has been such as to distribute the different treatments over practically the whole 2 acres, thus eliminating, as far as possible, local inequalities of soil.

The surface foot of soil was sampled, beginning the last of April and closing August 26, once each week; the second foot, every two weeks; and the third and fourth feet, at the beginning, in the middle, and at the close of the season. Plant samples were collected weekly after the plants had attained sufficient size.

The samples collected, whether of soils or plants, were in every case made composites of units collected from the 4 subplots under each treatment, taken as nearly along middle lines of the 3 plots and as near the centers of the several subplots as practicable.

In applying the fertilizers the same methods were followed in all places. The guano was bought of one dealer and subdivided for the four localities. The stable manure at each station was first brought together and spread, load by load, over a small area, building up a single pile, and from this mixed pile the manure was hauled to the fields and each load distributed in such a manner that proportionate parts of each load were given to all subplots of a given soil type. Both manure and fertilizers were spread broadcast and well plowed under, using large plows in the South as well as in the North.

The same seed was used at all places, Iowa Goldmine for corn and Rural New Yorkers for seed potatoes, all procured from the same dealer at Minneapolis, Minn. The planting was done in the same manner and on the same dates at the four places, and the crops were given similar treatment.

The sampling of both soil and plants was carried through the season as planned, but changes in arrangement have rendered it impossible to make all of the soluble salt determinations, and those under the corn are the only ones which have been systematically examined for the whole season.

Meteorological Conditions Affecting the Crops.

RAINFALL.

A record was kept of the rainfall for the four stations where these comparative studies were made, and in the next table there are given the essential data.

Table of the lightest and the heaviest rainfall of any one day in each consecutive 10-day period for the growing season, and the total rainfal by periods—1903.

Ten-day period.	Goldsboro, N. C.			Upper Marlboro, Md.			Lancaster, Pa.			Janesville, Wis.		
	Lightest rainfall in period.	Heaviest rainfall in period.	Total rainfall of period.	Lightest rainfall in period.	Heaviest rainfall in period.	Total rainfall of period.	Lightest rainfall in period.	Heaviest rainfall in period.	Total rainfall of period.	Lightest rainfall in period.	Heaviest rainfall in period.	Total rainfall of period.
	In.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
April 24 to May 3	0.40	0.85	1.25	0.07	0.08	0.15	0.20	0.20	0.20	0.05	0.09	0.14
May 4 to 13	.21	.21	.21	.00	.00	.00	.00	.00	.00	.13	.17	.30
May 14 to 23	.08	.08	.08	.17	.42	.59	.04	.16	.20	.13	.19	.32
May 24 to June 2	.73	.83	1.56	.05	.45	1.23	.05	.23	.36	.07	1.43	3.10
June 3 to 12	.03	1.13	2.59	.01	2.01	2.79	.09	2.11	3.04	.25	.25	.25
June 13 to 22	.05	.30	.35	.02	1.46	3.01	.05	.55	1.68	.04	.05	.09
June 23 to July 2	.11	1.85	3.41	.08	.39	.73	.01	.60	.94	.02	1.29	1.47
July 3 to 12	.02	.88	.95	.08	1.44	2.31	.01	1.03	2.29	.21	1.22	3.26
July 13 to 22	.05	1.59	1.64	.01	2.00	4.44	.01	1.44	1.54	1.62	1.62	1.62
July 23 to August 1	.20	1.26	2.30	.04	.24	.47	.01	.11	.12	.26	.35	.61
August 2 to 11	.01	1.12	1.50	.01	.45	1.28	.03	1.10	2.50	.25	.85	1.40
August 12 to 21	.07	1.06	2.36	.02	.47	1.05	.08	.56	.95	1.70	1.70	1.70
August 22 to 31	.07	.18	.38	.04	.86	1.65	.01	2.52	3.84	.16	1.62	2.48
September 1 to 10	.24	.62	.86	.08	.08	.08	.01	.43	1.21	.18	1.50	2.01
Total	......	......	19.44	......	......	19.78	......	......	18.87	......	......	18.75
Longest period without rain.	7 days (July 20 to 26).			7 days (August 20 to 26).			9 days (July 20 to 28).			10 days (July 18 to 27).		

It will be seen that, very fortunately for this comparative study, both the character and the amounts of rainfall have been extremely similar at the four stations, the maximum difference in the amounts of rainfall being but 1 inch for the whole season. The longest period without rain has been but ten days at Janesville, nine days at Lancaster, and seven days at each of the other places. May 4 to May 23 was a period of small rainfall at all places alike, and July 3 to July 22 was a period of rather heavy rainfall alike for all places. The heaviest rainfall of any single day, 2.52 inches, occurred at Lancaster, but each of the other places had a rainfall of 1.7 inches, or more, in one day.

ABSOLUTE AMOUNT OF SOIL MOISTURE.

There have been given in various tables of this bulletin data regarding the water content of these soils. In the next table are given, in inches, the absolute maximum and minimum amounts carried by each of the soil types under consideration and the average amounts for the season and for each foot of depth.

Maximum, minimum, and average amounts of soil moisture found in 8 soil types—1903.

MAXIMUM AMOUNTS OF SOIL MOISTURE.

Depth.	Goldsboro, N. C.		Upper Marlboro, Md.		Lancaster, Pa.		Janesville, Wis.	
	Norfolk sandy soil.	Selma silt loam.	Norfolk sand.	Sassafras sandy loam.	Hagerstown clay loam.	Hagerstown loam.	Janesville loam.	Miami loam.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
Surface foot	2.56	2.97	2.82	2.96	3.81	3.79	3.81	2.89
Second foot	3.40	4.07	3.63	3.42	4.27	4.35	3.77	2.91
Third foot	4.68	4.93	3.75	4.02	4.88	5.19	4.03	2.54
Fourth foot	5.28	5.42	3.11	4.48	5.41	5.41	4.69	2.56
Total	15.92	17.39	13.31	14.88	18.37	18.74	16.30	10.90

MINIMUM AMOUNTS OF SOIL MOISTURE.

Depth.	Norfolk sandy soil.	Selma silt loam.	Norfolk sand.	Sassafras sandy loam.	Hagerstown clay loam.	Hagerstown loam.	Janesville loam.	Miami loam.
Surface foot	1.27	2.21	1.44	1.60	2.38	2.43	3.11	2.32
Second foot	2.63	3.35	2.33	2.44	3.61	3.70	3.04	2.43
Third foot	3.54	3.91	2.85	2.99	4.84	4.77	3.29	2.02
Fourth foot	3.88	4.89	2.37	3.43	5.33	5.32	4.05	2.14
Total	11.32	14.36	8.99	10.46	16.36	16.22	13.49	8.91

AVERAGE AMOUNTS OF SOIL MOISTURE.

Depth.	Norfolk sandy soil.	Selma silt loam.	Norfolk sand.	Sassafras sandy loam.	Hagerstown clay loam.	Hagerstown loam.	Janesville loam.	Miami loam.
Surface foot	1.94	2.61	2.10	2.37	3.06	3.03	3.41	2.75
Second foot	2.85	3.85	3.00	2.95	3.96	3.90	3.36	2.67
Third foot	3.93	4.57	3.38	3.61	4.86	4.91	3.61	2.24
Fourth foot	4.36	5.07	2.76	4.05	5.33	5.35	4.32	2.32
Total	13.08	16.10	11.24	12.98	17.21	17.19	14.70	9.98

From this table it will be seen that the Pennsylvania soils have carried the largest amounts of water at all times, ranging between 16.3 and 18.5 inches in the 4 feet. The Miami loam has carried the smallest amount, ranging between 9 and 11 inches.

DIFFERENCES OF SOIL TEMPERATURE.

Throughout the season at the 4 stations the soil temperatures were recorded at 4 depths for each of the soil types by means of mercurial thermometers, read once per week on the same date at all stations and between 1.30 p. m. and 4 p. m. In the following table are recorded the mean temperatures of each soil type for the season at the 4 depths, and also the temperatures at the beginning and close of the season.

Temperatures of 8 soil types at 4 depths—1903.

TEMPERATURES, APRIL 25.

Depths.	Goldsboro, N. C.		Upper Marlboro, Md.		Lancaster, Pa.		Janesville, Wis.	
	Norfolk sandy soil.	Selma silt loam.	Norfolk sand.	Sassafras sandy loam.	Hagerstown clay loam.	Hagerstown loam.	Janesville loam.	Miami loam.
	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*
6 inches	58.0	58.1	57.0	55.5	51.0	48.6	47.6	49.0
12 inches	56.2	56.5	54.5	52.5	50.0	48.2	45.8	45.7
24 inches	56.5	56.5	53.0	51.8	49.2	47.7	44.5	44.1
36 inches	57.0	57.0	51.6	51.0	49.0	47.5	43.2	42.9

Temperatures of 8 soil types at 4 depths—1903—Continued.

TEMPERATURES, SEPTEMBER 12.

Depths.	Goldsboro, N. C.		Upper Marlboro, Md.		Lancaster, Pa.		Janesville, Wis.	
	Norfolk sandy soil.	Selma silt loam.	Norfolk sand.	Sassafras sandy loam.	Hagerstown clay loam.	Hagerstown loam.	Janesville loam.	Miami loam.
	° F.	*° F.*	*° F.*	*° F.*	*° F.*	*° F.*	*° F.*	*° F.*
6 inches	87.7	85.4	76.5	75.2	73.4	73.3	67.5	69.4
12 inches	81.6	79.1	75.0	71.0	67.5	68.0	64.5	66.2
24 inches	79.5	77.9	71.5	70.8	66.6	67.4	62.2	63.7
36 inches	78.7	76.4	69.7	68.8	65.0	65.3	61.6	63.4
MEAN TEMPERATURE FOR THE SEASON.								
6 inches	79.46	77.63	72.18	70.40	67.84	67.49	64.05	65.29
12 inches	74.92	73.40	69.67	67.50	65.42	64.65	61.[illegible]0	62.23
24 inches	73.39	71.76	67.93	66.15	63.74	63.21	59.15	60.38
36 inches	72.35	70.28	65.68	64.22	61.77	61.31	57.53	58.85

From the table it will be seen that the Goldsboro soils have been warmest and the Janesville soils coldest, at all depths, and throughout the season. In April there was a difference between these two places of 9.7° F. at the surface and 14° F. at 36 inches. On September 12 the differences were 18.1° F. at 6 inches and 14.05° F. at 36 inches.

Referring to the two soil types at the same station, it will be seen that at both Goldsboro and Upper Marlboro there is a mean difference of about 2° F., and of 1.3° F. at Janesville, while at Lancaster there is but little difference at any level. In all cases the soil carrying the greatest absolute amount of water has been the colder in each locality.

RATE OF EVAPORATION AT THE FOUR STATIONS.

The rates of evaporation at the 4 stations were measured in two ways: (1) From a soil surface maintained continuously saturated by capillarity and having an area of 11.066 square feet; (2) from a plant evaporimeter bearing and maturing 10 stalks of corn, having the same area as the soil evaporimeter and filled with the same soil. The Norfolk sandy soil was used at Goldsboro, the Norfolk sand at Upper Marlboro, the Hagerstown clay loam at Lancaster, and the Janesville loam at Janesville. The next table gives the observed daily evaporation from the four soil types as measured by the two evaporimeters.

Rates of evaporation from wet soil surfaces and from growing corn at 4 stations—1903.

	Goldsboro, N. C.	Upper Marlboro, Md.	Lancaster, Pa.	Janesville, Wis.
	Inches.	*Inches.*	*Inches.*	*Inches.*
Mean daily evaporation from soil	0.212	0.192	0.153	0.18
Mean daily evaporation from plants	.259	.161	.191	.213

From the table it appears that the mean daily rate of evaporation was largest at Goldsboro and least at Lancaster, from the wet soil surface. From the corn plants, and the soil surface upon which they

grew, it was also greatest at Goldsboro and least at Lancaster, leaving out of comparison the one at Marlboro on account of the poor growth which the plants made. It is noteworthy that there is less difference in the rate of evaporation between the plant evaporimeters, under the different climatic conditions, than there is between the loss of water from the wet soil surfaces.

The evaporation under both conditions has much exceeded the rainfall for the period, and still more has it exceeded the absolute maximum amount of water observed in the surface 4 feet of the field soils.

Mean Yields of Corn and Potatoes from the Eight Soil Types.

The mean yields of both corn and potatoes, which were secured from each of the 8 soil types, treated in every way alike and under the conditions of entirely normal good field culture, are given in the next table.

Mean yields of corn and potatoes on 8 soil types under 5 degrees of fertilization—1903.

TOTAL GREEN CORN (WHOLE PLANTS), POUNDS PER ACRE.

Fertilizer per acre.	Goldsboro, N. C.		Upper Marlboro, Md.		Lancaster, Pa.		Janesville, Wis.	
	Norfolk sandy soil.	Selma silt loam.	Norfolk sand.	Sassafras sandy loam.	Hagerstown clay loam.	Hagerstown loam.	Janesville loam.	Miami loam.
Nothing	5,080.1	8,986.8	5,194.9	5,983.2	10,762.2	13,307.0	24,922.2	17,866.8
5 tons manure	8,330.4	9,580.6	7,843.2	9,248.9	13,183.2	13,273.1	25,544.5	22,467.5
10 tons manure	11,766.7	10,044.0	9,297.0	10,796.5	14,895.3	14,576.7	26,228.6	23,448.2
15 tons manure	14,543.5	10,299.9	10,949.0	10,959.4	15,224.5	13,510.1	27,204.0	25,384.0
300 pounds guano	8,887.5	8,445.4	6,852.4	8,175.1	12,630.0	14,627.5	24,346.8	19,518.9
Average	9,701.6	9,471.3	8,027.3	9,032.6	13,339.0	13,858.9	25,649.2	21,737.1

TOTAL AIR-DRY CORN (WHOLE PLANTS), POUNDS PER ACRE.

Fertilizer per acre.	Norfolk sandy soil.	Selma silt loam.	Norfolk sand.	Sassafras sandy loam.	Hagerstown clay loam.	Hagerstown loam.	Janesville loam.	Miami loam.
Nothing	3,647.2	5,878.6	3,130.2	4,465.6	7,309.4	9,667.0	16,239.4	11,147.3
5 tons manure	6,031.2	6,354.8	5,343.6	6,303.1	9,495.6	9,836.3	17,395.2	13,686.0
10 tons manure	8,311.0	6,685.8	6,464.2	8,301.6	11,313.0	10,513.5	17,412.4	14,676.2
15 tons manure	10,016.9	7,115.5	7,390.3	7,818.5	10,799.4	10,293.4	17,464.3	15,276.3
300 pounds guano	6,014.6	5,580.2	4,732.5	4,494.9	8,995.1	10,293.4	16,041.9	11,893.1
Average	6,804.2	6,323.0	5,412.1	6,276.7	9,582.5	10,120.8	16,910.6	13,335.8

SHELLED CORN CONTAINING 10 PER CENT MOISTURE, BUSHELS PER ACRE.

Fertilizer per acre.	Norfolk sandy soil.	Selma silt loam.	Norfolk sand.	Sassafras sandy loam.	Hagerstown clay loam.	Hagerstown loam.	Janesville loam.	Miami loam.
Nothing	18.59	36.61	17.56	24.47	38.88	55.17	78.08	56.36
5 tons manure	29.64	38.12	29.65	28.21	47.54	54.44	81.31	71.63
10 tons manure	42.83	41.47	33.01	35.35	60.13	55.01	85.61	74.22
15 tons manure	57.34	43.87	39.58	37.11	64.95	51.44	76.12	82.02
300 pounds guano	32.91	34.38	28.55	22.40	52.86	57.36	81.02	62.34
Average	36.26	38.89	29.55	29.51	52.88	54.68	80.43	69.31

TOTAL POTATOES, BUSHELS PER ACRE.

Fertilizer per acre.	Norfolk sandy soil.	Selma silt loam.	Norfolk sand.	Sassafras sandy loam.	Hagerstown clay loam.	Hagerstown loam.	Janesville loam.	Miami loam.
Nothing	21.5	57.5	61.46	75.42	132.68	137.90	215.3	188.3
5 tons manure	38.1	76.0	112.67	101.63	167.74	159.39	280.2	237.2
10 tons manure	70.9	78.4	132.81	101.63	180.91	165.95	329.9	267.3
15 tons manure	67.3	72.8	132.62	115.10	206.92	179.49	346.9	280.7
300 pounds guano	40.8	67.2	73.82	73.00	151.78	142.24	282.2	211.9
Average	47.7	70.4	102.68	93.36	168.01	156.99	290.5	237.1

It should be said, regarding these yields, that in the case of the corn the results represent the best which could be expected from good treatment for a single season, taking the fields as they were found.

The Janesville loam was, perhaps, in the best condition of any one of the soils, on account of its previous treatment. It was part of a dairy farm and had received frequent liberal dressings of stable manure. The Miami loam was part of a farm which had been rented for a term of years and had been, during that time, badly managed, but in the hands of the recent purchaser was being brought back into condition.

The Hagerstown clay loam had been in pasture for a number of years and was under sod when taken for this work. The Hagerstown loam had received occasional moderate dressings of stock-yard manure with some mineral fertilizers.

The 2 Maryland and 2 North Carolina soils had certainly, in their previous treatment, received less rational handling and were undeniably in relatively poorer condition than the other 4 soils.

These differences in the soils which were chosen were sought rather than avoided for the purposes of this preliminary investigation, as has been stated, one of the prime objects of the study being to see if good and poor soil management are reflected in the character of the water-soluble salt content of the soil.

Relation of Yields to the Amounts of Water-Soluble Salts Recovered.

In this comparative study 8 soil types have been chosen, 2 in each of 4 States, and in each soil the water-soluble salts have been made, presumably, different in different subplots by the addition of no fertilizer or of 5, 10, and 15 tons of stable manure, or 300 pounds of guano per acre, as indicated in the diagram (p. 108), each of the 5 degrees of fertilization being repeated 4 times on 2 acres. It had been the purpose to have complete chemical analyses made of the manures and of the fertilizer used, as well as of the soils to which they were applied, but this has not been done.

In the next table there are brought together the mean yields of both crops—corn and potatoes—from the 8 soils, for the purpose of showing their relation to the water-soluble salts which have been recovered from the soils at different times during the season after the fertilizers had been added and the crops were growing upon the ground.

Mean amounts of water-soluble salts recovered from the surface foot of 8 soil types with 5 degrees of fertilization under corn, together with data regarding the crop—1903.

Reference number.	Items.	Subplots fertilized with— Nothing.	5 tons manure.	10 tons manure.	15 tons manure.	300 pounds guano.
	Crop yields per acre:					
1	Air-dry stalks and ears........pounds..	7,686	9,302	10,460	10,772	8,506
2	Shelled corn, 10 per cent water........bushels..	40.72	47.57	53.46	56.56	46.48
3	Potatoes........do....	111.26	146.62	165.96	175.23	130.37
	Moisture in soil:					
4	Per cent........	19.03	19.30	18.92	19.48	19.49
5	Inches........	2.65	2.68	2.64	2.66	2.65
6	Mean dry weight of soil........pounds per cubic foot..	73.36	73.55	73.18	72.12	73.67
	Salts recovered, in parts per million of dry soil:					
7	K........	14.04	15.37	16.17	17.36	14.78
8	Ca........	69.30	69.37	70.74	74.27	81.23
9	Mg........	21.44	22.11	23.60	24.22	24.07
10	NO_3........	29.12	30.95	30.47	32.47	30.38
11	HPO_4........	13.98	14.73	16.04	15.01	13.77
12	SO_4........	115.40	116.32	118.31	125.07	146.28
13	HCO_3........	38.00	44.94	49.30	49.54	52.85
14	Cl........	1.12	.92	1.21	1.84	1.42
15	SiO_3........	19.04	19.28	18.80	17.93	18.49
16	Total........	321.44	333.99	344.64	357.71	383.27
17	Total salts recovered........pounds per acre-foot..	1,027	1,070	1,098	1,186	1,230
18	Increase of water-soluble salts[a]......pounds per acre..	....	43	71	159	203
19	Increase of corn[a]........bushels per acre..	....	6.85	12.74	15.84	5.76

[a] Found by subtracting totals for unfertilized plots from totals for other plots, respectively.

It should be understood that the data in this table are made up as follows:

The yields in every case are averages from 32 subplots, 8 from each of 4 States.

The moisture determinations, the weight of dry soil, and all soluble-salt determinations are derived from samples collected on 6 dates. As there are 8 soils and 6 determinations of each, each value in the table is an average of 48 analyses.

From the above table it will be seen—

(1) From lines 1, 2, 3, and 19 (reference numbers in first column of table), that the yields of both corn and potatoes have increased with the increased amounts of stable manure added, and in the case of the corn, somewhat proportionately to them.

(2) From lines 4, 5, and 6, that there is little indication of a measurable effect of the fertilizers added to the soil upon either the amount of moisture or the weight of the dry soil per cubic foot, although it must be said that the plots to which the 10 and 15 tons of stable manure were added are the lightest, and that the 15-ton plots average less than the 10-ton plots, as was to be anticipated, while in the plots to which the guano was applied the soil is the heaviest of them all.

(3) From line 7, that the amounts of potash recovered from the subplots show the same order of increase that the yields of corn and potatoes show.

(4) From line 8, that in the case of lime there is scarcely a measurable difference under the different treatments until the largest amount of manure is reached. With the guano there is a very measurable increase of lime over all the other plots, and this appears to be fully in accord with absorption studies where potash and ammonia become fixed simultaneously with the forcing of lime into solution. It should not perhaps be overlooked that there is an increase in lime from the lowest to the highest fertilization with manure.

(5) From line 9, that the amounts of magnesia recovered follow the same general order of increase as do the potash and the crop yields, but the differences are small, although the absolute amounts recovered are greater than those of potash.

(6) From line 10, that the nitrates show little tendency to an orderly increase, the 5-ton and 15-ton plots being the highest, and the "nothing-added" plots lowest, as would be expected; but it is well established that nitrates in the soil decrease rapidly under vigorous growth.

(7) From line 11, that the 10-ton plots show the largest amounts of phosphoric acid and the guano plots least, the general indication being that the influence on soluble phosphates was not measurable.

(8) From line 12, that compared with other ingredients recovered the SO_4 is very high and shows the same order of increase as the lime does, but it is not enough to chemically combine with it, forming sulphate.

(9) From line 13, that the HCO_3 shows the same order of increase as the lime and SO_4, all three being highest in the subplots to which the guano had been applied.

(10) From line 14, that the amounts of chlorides are very small, too small for measurement by the method used.

(11) From line 15, that the amounts of SiO_2 recovered from the soil are not markedly influenced by the different degrees of fertilization, the influence, if any, being to decrease the amounts recovered and perhaps more with the larger quantities of manure applied.

(12) From lines 16 and 17, that the total salts show the same order of increase as the crop yields, except in case of the guano plots.

(13) From lines 18 and 19, that there is, roughly, a quantitative relation between the increase in the recovered amounts of total salts from the *manured* subplots corresponding with that of the yields of corn from the same subplots.

The relations between the yields; the amounts of fertilizers applied; the water-soluble potash; the sums of the K, NO_3, HPO_4; and the total salts recovered during the 3-minute washings of the soil samples are brought out clearly in the accompanying chart (fig. 6). From this graphic illustration of the relations there is shown a rather remarkable concordance between the yields and the recovered potash, and a com-

parison of this curve with that of the combined potash, nitric acid, and phosphoric acid appears to indicate that the variations in the amounts of potash, in soluble form in the soil, have been more influential in determining differences in yields than have those of the other ingredients studied.

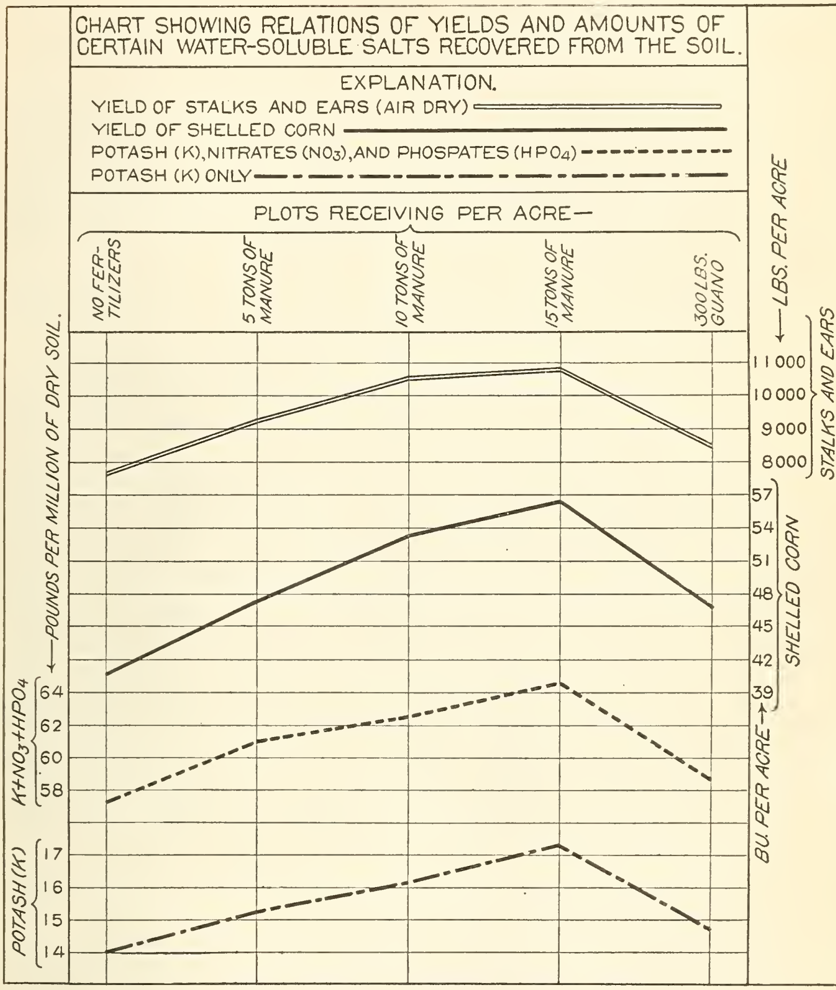


FIG. 6.—Chart showing relations of yields and amounts of certain water-soluble salts recovered from the surface foot of the same soils with five grades of fertilization.

COMPARISON OF THE YIELDS FROM EIGHT SOIL TYPES WITH THE AMOUNTS OF WATER-SOLUBLE SALTS RECOVERED FROM THEM.

In the last section was shown the relation of yields to the water-soluble salts recovered from 8 soil types, each of which had been subjected to 5 grades of fertilization, and it was seen that the yields rose

and fell with the rise and fall of potash recoverable by 3-minute washings of the soil in distilled water. It was observed that the yields varied to a marked extent with small but nevertheless measurable amounts of potash. The results showed that the methods developed for this work may be so handled as to show differences in the water-soluble salts recoverable from soils such as are produced by the application of 5, 10, and 15 ton lots of stable manure and of 300 pounds of guano per acre.

The comparison to be made here is on the same 8 types of soil, but grouping the data so as to compare the yields and the water-soluble salts as well, from the separate types of soil, irrespective of the fertilization, to see if similar measurable relations are shown to exist among the different soil types. The next table presents the data grouped in this way.

Crop yields, soil moisture, and amounts of water-soluble salts recovered from the surface foot of each of the 8 soil types—1903.

Item.	Norfolk sandy soil.	Selma silt loam.	Norfolk sand.	Sassafras sandy loam.	Hagerstown clay loam.	Hagerstown loam.	Janesville loam.	Miami loam.
Yields per acre:								
Stalks and ears, pounds	6,804	6,323	5,412	6,277	9,583	10,121	16,911	13,336
Shelled corn, 10 per cent water, bushels	36.26	38.89	29.55	29.51	52.88	54.68	80.43	69.31
Potatoes, bushels	47.70	70.40	102.68	93.36	168.01	156.99	290.50	237.10
Mean soil moisture:								
Per cent	13.76	18.85	12.93	16.35	22.64	20.60	27.44	21.16
Inches	2.21	2.77	2.13	2.45	2.81	2.62	3.43	2.89
Mean dry weight soil, pounds per cubic foot	82.54	74.73	82.34	78.43	64.93	66.08	65.22	71.21
Salts, parts per million of dry soil:								
K	12.19	12.88	11.38	10.71	13.77	26.42	20.23	16.77
Ca	38.67	54.87	39.62	52.39	114.20	96.21	96.79	91.17
Mg	12.64	12.70	10.31	10.95	43.80	33.99	30.40	29.93
NO_3	21.74	20.19	12.31	17.52	29.85	37.70	63.51	42.58
HPO_4	10.73	10.87	10.98	10.55	16.61	16.94	24.56	16.40
SO_4	49.17	86.42	56.40	69.83	224.80	204.18	151.73	151.78
HCO_3	25.23	14.17	19.73	20.27	127.13	93.40	39.93	35.53
Cl	1.47	2.00	1.40	1.87	.87	.67	1.27	.87
SiO_2	10.18	12.84	5.09	5.62	19.31	22.64	39.77	34.20
Sum	182.02	226.94	167.22	199.71	590.34	532.15	468.19	419.23

In this table each yield is an average of 5 grades of fertilization repeated 4 times, or 20 subplots.

As the water-soluble salts were determined on 6 different dates for each of the 5 grades of fertilization, each moisture and salt value in the table is an average of 30 determinations on each soil type.

The relations of the crop yields, the potash alone, the potash plus the nitrates plus the phosphates, and the total salts recovered from the 8 soil types are shown by the platted curves in the accompanying chart (fig. 7). In this chart the soils have been so arranged that the weaker and the stronger soils alternate, the black circles (●) appearing on the perpendicular lines which represent the stronger soils and the open circles (○) on those which represent the weaker soils.

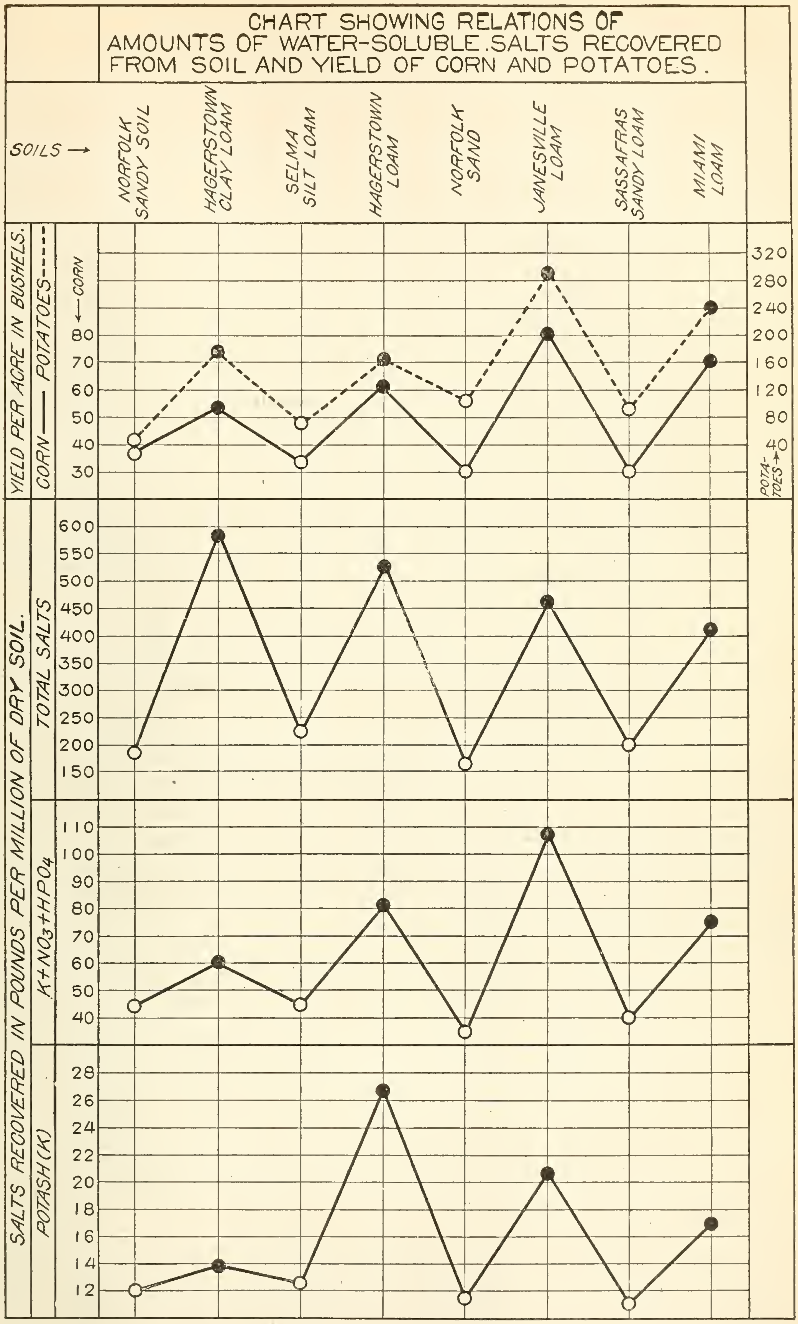


FIG. 7.—Chart showing relations of the amounts of water-soluble salts recovered from the surface foot of eight soil types in four States, and the yields of corn and potatoes grown thereon. The soils are so arranged that the weaker and stronger alternate. The open circles (○) are on the vertical lines representing weaker soils, and the black circles (●) on those representing stronger soils.

From this diagram there appears an evident relation between the yields of corn and potatoes and the amounts of potash which have been recovered from the soils upon which the crops have grown. It is further seen that, when a curve is constructed for the sums of the K, NO_3, and HPO_4, its concordance with the curve for yield is good—perhaps even better than that of the potash alone. So, too, when the total salts are compared with the yield as is done in the diagram there is a good concordance so far as the 2 groups of soils are concerned.

In a broad way, too, it must be said of the 2 groups of soils—the 4 soils which have given low yields and the 4 which have given high yields—that every salt determined, except chlorine, shows a larger amount recovered from the soils which have produced the large yields, and the contrast is so strong that such a relation must be conceded as existing in these particular soils. Beyond this generalization it would be unwise to go without further investigation.

On three different dates the water-soluble salts were determined for the surface 4 feet on each type of soil and the results are given in the next table for the sake of brevity as the sums of the parts per million of dry soil recovered from the 4 feet.

Mean amount of water-soluble salts recovered from the surface 4 feet of 8 soil types at the beginning, middle, and close of the growing season, together with data regarding crop yields, soil moisture, etc.—1903.

Item.	Norfolk sandy soil.	Selma silt loam.	Norfolk sand.	Sassafras sandy loam.	Hagerstown clay loam.	Hagerstown loam.	Janesville loam.	Miami loam.
Yields per acre:								
Stalks and ears, pounds	6,804	6,323	5,412	6,277	9,583	10,121	16,911	13,336
Shelled corn, 10 per cent water, bushels	36.26	38.89	29.55	29.51	52.88	54.68	80.43	69.31
Potatoes, bushels	47.70	70.40	102.68	93.36	168.01	156.99	290.50	237.10
Mean dry weight, soil, pounds per cubic foot	101.34	83.00	94.00	85.39	89.97	91.15	83.25	85.44
Mean soil moisture:								
Per cent	17.05	23.26	15.03	19.74	24.70	23.77	23.40	16.63
Inches	3.41	3.75	2.74	3.25	4.25	4.18	3.69	2.70
Salts, parts per 4 million of dry soil:								
K	47.52	42.73	46.46	47.09	48.92	60.42	99.95	67.98
Ca	91.58	114.90	94.54	100.83	264.41	223.42	293.60	277.67
Mg	44.69	45.07	42.24	47.49	78.03	69.12	115.22	102.13
NO_3	36.67	26.76	35.93	34.33	66.82	105.31	153.65	52.83
HPO_4	31.97	33.33	46.80	36.47	56.32	48.13	92.16	76.10
SO_4	186.92	215.78	150.50	249.35	364.82	314.68	653.60	549.37
HCO_3	70.20	17.47	36.60	22.27	114.00	77.00	70.00	93.20
Cl	13.33	16.40	8.47	11.47	10.50	13.50	5.70	7.50
SiO_2	86.75	75.21	51.09	54.91	80.58	95.05	206.53	119.02
Sum	609.63	587.65	512.63	604.21	1,084.40	1,006.63	1,690.41	1,345.80
Salts in pounds per acre for surface 4 feet:								
K	209.75	154.47	190.21	175.13	191.72	246.03	364.42	256.90
Ca	404.23	415.36	387.05	374.99	1,036.22	909.77	1,070.47	1,049.31
Mg	197.26	162.93	172.93	176.62	305.80	281.46	420.09	385.95
NO_3	161.86	96.74	147.10	127.67	261.87	428.82	560.21	199.64
HPO_4	141.12	120.49	191.60	135.63	220.72	195.99	336.02	287.58
SO_4	825.06	780.04	616.15	927.33	1,429.73	1,281.38	2,383.03	2,076.07
HCO_3	309.86	63.15	149.84	82.82	459.19	313.54	255.22	352.20
Cl	58.84	59.29	34.68	42.66	42.29	54.97	20.78	28.34
SiO_2	382.91	271.88	209.16	204.21	324.58	387.04	753.01	449.78
Total	2,690.9	2,124.4	2,098.7	2,247.1	4,272.1	4,099.0	6,163.3	5,085.8

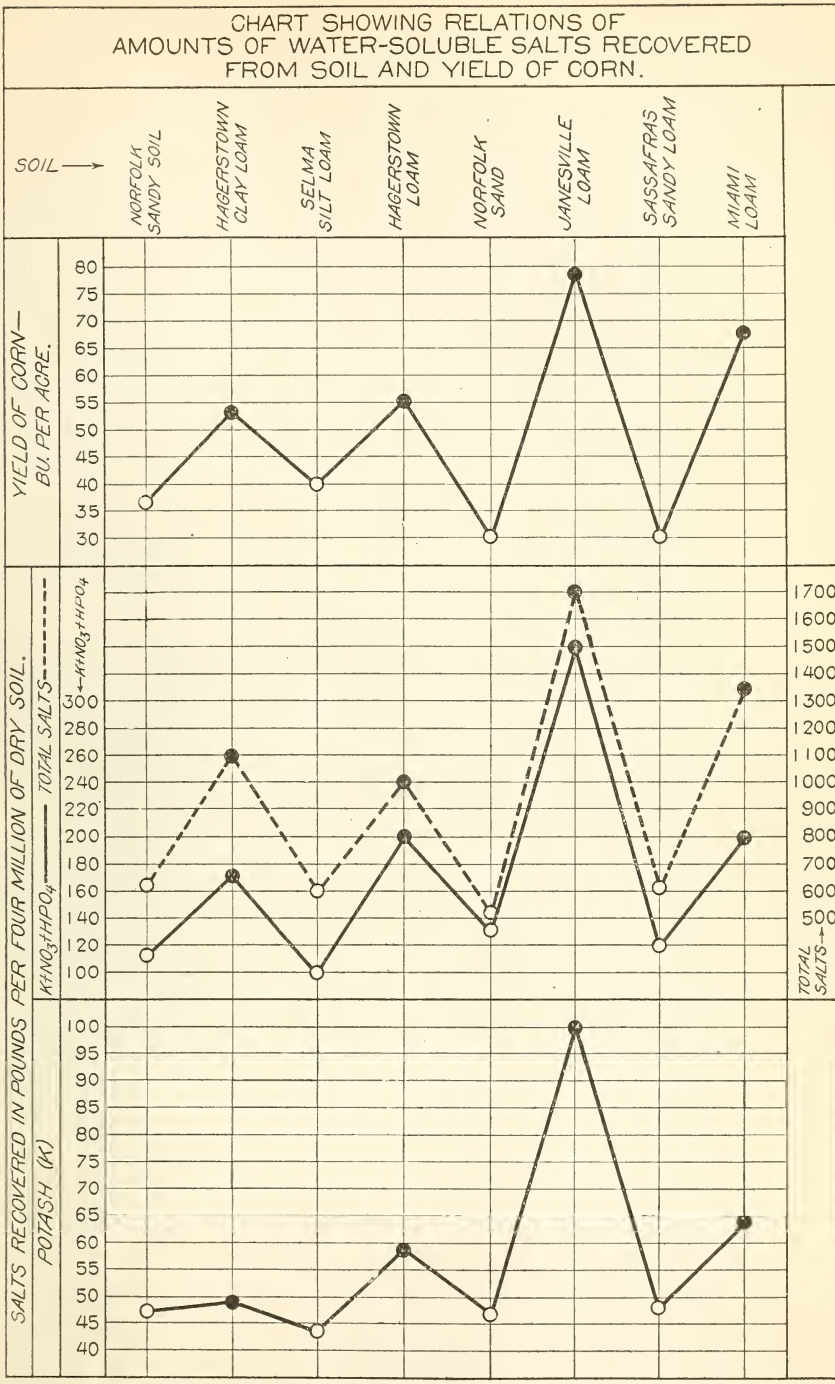


FIG. 8.—Chart showing relations of the amounts of water-soluble salts recovered from the surface 4 feet of eight soil types in four States, and the yields of corn grown thereon. The open circles (○) appear on the vertical lines representing the poorer soils, and the black (●) circles on those representing the stronger soils.

The figures in this table are the sums of the parts per million of recovered water-soluble salts, as determined separately for each of the surface 4 feet of all subplots, at the beginning and at the middle of the growing season; and both under and between hills of corn on the 15-ton subplots at the close of the season. Each value in the table is the result of 28 independent determinations.

It will be seen from the foregoing table and from the plotted curves in the chart (fig. 8)—which is constructed on the same plan as the preceding chart (fig. 7)—that the water-soluble salts which have been recovered from the surface 4 feet of soil under the corn show a well-marked rise and fall, corresponding even more strongly than in the 2 preceding cases, with the variations in yields. For the poorer soils the agreement is not so good as it was in case of the data for surface foot, but this is perhaps not strange in view of the small differences of yield and of the known much shallower rooting of crops in southern soils.

Relation of Crop Yields to Water-Soluble Salts Recovered from Eight Soil Types by Eleven Times Washing in Distilled Water with Alternate Drying Between the Washings.

In two other series of observations the same samples of surface soil were washed in distilled water 11 times by percolating through them 5 times their weight of water in each washing and making determinations of the several ingredients for each separate washing. The results are given as the mean sums of the separate determinations of the two series in the next table. The soils washed represent in the first series the surface foot of the unfertilized subplots, the samples being from a large composite of cores taken from all the unfertilized subplots under the three crop conditions. The soils for the second series were from composites of the surface foot from the subplots receiving 15 tons of manure, which were made up of 24 cores from each soil type.

The method of treating these samples and the fuller data are given on pages 68–70. The data grouped to show the relation of the salts recovered to the yields from the several soils are given in the following table and are represented graphically in figure 9:

Crop yields on 8 soil types and mean amounts of water-soluble salts recovered by washing samples of the same soils 11 times by percolating through them distilled water—1903.

Item.	Norfolk sandy soil.	Selma silt loam.	Norfolk sand.	Sassafras sandy loam.	Hagerstown clay loam.	Hagerstown loam.	Janesville loam.	Miami loam.
Yields per acre:								
Stalks and ears, pounds	6,804	6,323	5,412	6,277	9,583	10,121	16,911	13,336
Shelled corn, 10 per cent water, bushels	36.26	38.89	29.55	29.51	52.88	54.68	80.43	69.31
Potatoes, bushels	47.70	70.40	102.68	93.36	168.01	156.99	290.50	237.10
Mean dry weight soil, pounds per cubic foot	82.54	74.73	82.34	78.43	64.93	66.08	65.22	71.21
Mean soil moisture:								
Per cent	17.05	23.26	15.03	19.74	24.70	23.77	23.40	16.63
Inches	3.41	3.75	2.74	3.25	4.25	4.18	3.69	2.70
Salts, parts per million of dry soil:								
K	133.25	209.58	161.49	177.57	221.12	215.96	266.96	213.55
Ca	102.13	208.75	180.38	278.75	743.00	753.38	819.13	668.00
Mg	76.40	83.78	86.34	92.65	306.82	345.88	287.07	229.65
NO_3	40.12	55.84	35.71	51.84	131.06	99.91	89.59	82.26
HPO_4	67.11	101.01	61.01	75.65	127.38	110.44	396.09	285.97
SO_4	326.70	540.50	492.25	546.50	1,106.00	1,121.25	1,264.00	1,011.25
HCO_3	109.00	163.00	182.00	229.00	609.00	716.50	418.00	395.50
Cl	3.00	3.00	2.00	2.00	0.00	1.00	2.00	1.00
SiO_2	93.93	133.05	110.10	132.15	223.14	216.05	306.25	279.55
Sum	951.6	1,498.5	1,311.3	1,586.1	3,467.5	3,580.4	3,849.1	3,166.7
Salts, pounds per acre in surface foot:								
K	479.3	682.3	579.2	606.8	625.4	607.6	758.5	662.6
Ca	367.5	660.1	647.1	952.5	2,102.0	2,168.5	2,827.0	2,072.0
Mg	274.7	272.7	309.7	316.6	689.3	995.7	815.6	565.9
NO_3	144.3	181.8	128.1	177.1	370.8	287.6	254.5	353.0
HPO_4	241.4	328.8	215.6	264.4	360.4	317.8	1,125.5	704.7
SO_4	1,175.0	1,759.0	1,766.0	1,867.0	3,128.0	3,492.0	3,591.0	3,158.0
HCO_3	391.9	530.6	652.8	782.4	1,722.0	2,063.0	1,187.5	1,227.0
Cl	10.8	9.8	7.2	6.8	0.0	2.9	5.7	3.1
SiO_2	337.7	433.3	334.9	453.1	362.5	622.1	870.1	867.0
Total	3,422.6	4,858.4	4,640.6	5,426.7	9,360.4	10,557.2	11,435.4	9,613.3

In this table the amounts of water-soluble salts are derived from the results of 22 separate determinations, except in those cases, where, after a number of washings had been made, no salts of certain kinds were found in the solutions.

A study of the table and of the chart based upon it (fig. 9) will make it clear that there is a very striking agreement between the variations of yield and the variations in the amounts, not only of potash, but of phosphoric acid as well. The cases of the Sassafras sandy loam and the Hagerstown loam may, perhaps, be counted cases of discord, but there is no question but that, as a matter of fact, this soil type has a higher productive capacity than the Norfolk sand. In the case of the Hagerstown loam the matter is not so clear.

There is still in this series the very strong contrast between the two groups of soils where the differences in yield are large, much the larger amounts of salts soluble in water having been associated with the equally pronounced larger yields.

The evidence here presented, taken all in all, makes it clear that, in so far as the soils investigated are concerned, there is a well-marked

tendency for larger amounts of water-soluble salts to be recovered by the methods adopted from the soils upon which crops have made the largest yields. That the observed differences in yield are due to the

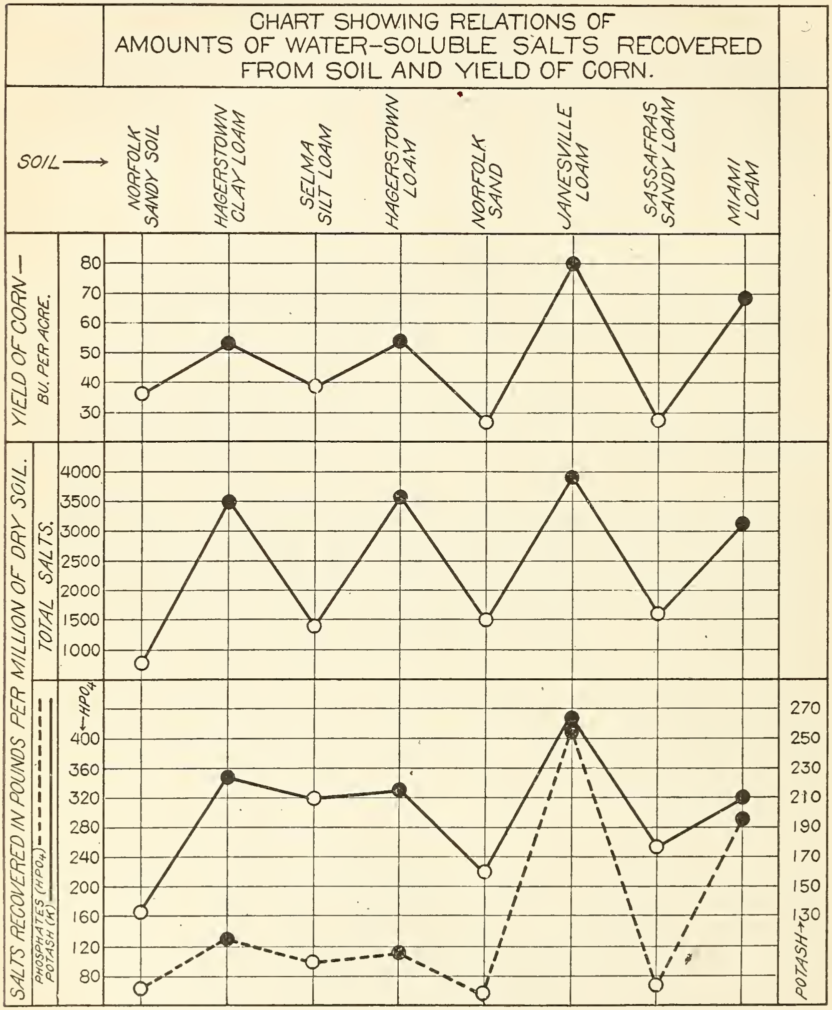


FIG. 9.—Chart showing relations of the amounts of water-soluble salts recovered by 11 times washing of samples from the eight soil types and the yields of corn grown thereon. The open circles (○) appear on the vertical lines representing the weaker soils, and the black circles (●) on those representing the stronger.

observed differences in the salts present in the soils is a distinctly different matter.

PART III.—RELATION OF DIFFERENCES OF CLIMATOLOGICAL ENVIRONMENT TO CROP YIELDS.

In connection with the critical studies made in 1903, relating to the amounts of water-soluble salts which may be recovered from soils, and in regard to the differences of yield associated with them, observations were also made regarding some of the climatological conditions affecting the soils and crops of the four localities.

RAINFALL AT THE FOUR STATIONS.

Location of Rain Gauges.

A record of the rainfall during the period of field observation was kept at the four stations, using standard Weather Bureau rain gauges suitably exposed in the open field. At Lancaster the gauge was stationed upon the Hagerstown clay loam area and about half a mile distant from the Hagerstown loam area. At Janesville the gauge was stationed on the Miami loam area and was about 1 mile distant from the field on the Janesville loam. At Upper Marlboro the gauge was near the field laboratory, between the two fields, about half a mile from the Sassafras sandy loam and 1 mile from the field on the Norfolk sand. At Goldsboro the gauge was stationed at the field laboratory, about 1 mile from the area on the Norfolk sandy soil and 1½ miles from the area on the Selma silt loam. It is known that in some cases the character of the rains was such that the indications of the gauge did not correctly express the rainfall on both fields and it would have been much better in a critical study of this character had there been provided a gauge for each field.

Records of Rainfall for the Four Stations.

In the next table are given the individual dates when rain fell and the amounts for each 24 hours from April 24 until the field season closed.

Individual dates of rainfall and the amounts for each day at the four substations during the growing season of 1903.

[Rainfall in inches.]

Date.	Goldsboro.	Marlboro.	Lancaster.	Janesville.
Period 1:				
April 24			T.	0.09
April 25	0.85	0.07	T.	.05
April 26	.40			
May 3		.08	0.20	
Sum	1.25	.15	.20	.14
Period 2:				
May 10	.21			
May 11				.13
May 13				.17
Sum	.21			.30
Period 3:				
May 17			.04	
May 19				.19
May 22		.17	T.	
May 23	.08	.42	.16	.13
Sum	.08	.59	.20	.32
Period 4:				
May 24	.73	.15		
May 25				.31
May 26		.39	.08	1.01
May 27		.14		1.43
May 28		.45		
May 29	T.		.23	
May 30		.05	.05	
May 31	.83	.05		.17
June 1				.07
June 2				.11
Sum	1.56	1.23	.36	3.10
Period 5:				
June 3	T.			
June 4	.09			T.
June 5	.03			T.
June 6	1.13	.58	.75	
June 7	.65	.16	.09	
June 8			.09	.25
June 9	.13	.03		T.
June 10	T.			T.
June 11	.56	2.01	2.11	T.
June 12		.01		
Sum	2.59	2.79	3.04	.25
Period 6:				
June 13		.06	.05	
June 14		.02	.36	
June 15				T.
June 16		1.46	.23	
June 17	.05		T.	
June 18			.09	T.
June 19			.06	.04
June 20	T.	1.41	.55	
June 21				T.
June 22	.30	.06	.34	.05
Sum	.35	3.01	1.68	.09
Period 7:				
June 23		.11	.33	
June 24	.11		T.	.05
June 25	.98			
June 26	1.85			
June 27		.08		
June 28	.47	.15	.60	
June 29		.39	.01	.11
July 1				.02
July 2				1.29
Sum	3.41	.73	.94	1.47
Period 8:				
July 3		0.11	1.03	1.22
July 4	.88	.46		
July 5		.22	.01	
July 6	.05			
July 8				.21
July 9				1.00
July 10			T.	.83
July 11		.08	.71	
July 12	.02	1.44	.54	
Sum	.95	2.31	2.29	3.26
Period 9:				
July 13	1.59	.04	.01	
July 14		.08	.01	
July 17				1.62
July 18			1.44	
July 19	.05	.51	.08	T.
July 20		1.80		T.
July 21		.01	T.	
July 22		2.00	T.	
Sum	1.64	4.44	1.54	1.62
Period 10:				
July 26				T.
July 27	.20			
July 28				.26
July 29		.24	.11	
July 30	1.26	.04	.01	
July 31	.31	.07		
August 1	.53	.12		.35
Sum	2.30	.47	.12	.61
Period 11:				
August 2		.01		
August 3	T.	.14	T.	.85
August 4	.01	.11	1.10	.30
August 5		.02	T.	T.
August 6	.06	.44	.72	
August 8	.31	.06	.03	.25
August 9			T.	T.
August 10	T.	.45		
August 11	1.12	.05	.65	
Sum	1.50	1.28	2.50	1.40
Period 12:				
August 12	.39			
August 13	.08	.15	.56	
August 14	.32	.02	.08	1.70
August 15	.24	.47	.12	
August 16			.11	T.
August 18	.20			
August 19	1.06	.41	.08	
August 20	.07			
August 21				T.
Sum	2.36	1.05	.95	1.70
Period 13:				
August 22				T.
August 23			.02	T.
August 24				.16
August 25			.48	
August 26				1.62
August 27	.18	.86	2.52	.22
August 28		.43	.40	.48
August 29		.32	.04	T.
August 30	.07	.04	.37	T.
August 31	.13		.01	
Sum	.38	1.65	3.84	2.48

Individual dates of rainfall and the amounts for each day at the four substations during the growing season of 1903—Continued.

Date.	Goldsboro.	Marlboro.	Lancaster.	Janesville.
Period 14:				
September 1	0.62		T.	
September 4				.18
September 6			.34	T.
September 7			.28	.33
September 8		.08	.43	
September 9			.01	1.50
September 10	.24		.15	
Sum	.86	.08	1.21	2.01
Period 15:				
September 11		.14		
September 13				1.35
September 14				.34
September 15				T.
September 16	.98	.05		
September 17	.17	.43	1.05	
September 18				T.
Sum	1.15	.62	1.05	1.69

Date.	Goldsboro.	Marlboro.	Lancaster.	Janesville.
Period 16:				
September 27		1.42	0.09	T.
Sum		1.42	.09	
Period 17:				
October 1				.10
October 2				T.
October 3				.38
October 6			.02	2.06
October 7			T.	T.
October 8			1.58	
October 9			1.66	
October 10			.62	
Sum			3.88	2.54
Period 18:				
October 11			.05	
October 14				.43
October 17			.58	
Sum			.63	.43

RAINFALL BY 10-DAY PERIODS.

Beginning with April 24 and ending with September 10 the amounts of rainfall have been combined in 10-day periods, and the results are shown in the following table, in which there are also given for each station the lightest and the heaviest rainfall on any single day on which rain fell in each period.

Table showing the lightest rainfall and the heaviest rainfall for one day, and the total rainfall at the 4 stations for each 10-day period from April 24 to September 10, inclusive, 1903.

[Rainfall in inches.]

Period.	Date.	Goldsboro, N. C.			Marlboro, Md.			Lancaster, Pa.			Janesville, Wis.		
		Lightest rainfall in period.	Heaviest rainfall in period.	Total rainfall of period.	Lightest rainfall in period.	Heaviest rainfall in period.	Total rainfall of period.	Lightest rainfall in period.	Heaviest rainfall in period.	Total rainfall of period.	Lightest rainfall in period.	Heaviest rainfall in period.	Total rainfall of period.
1	April 24 to May 3	0.40	0.85	1.25	0.07	0.08	0.15	0.20	0.20	0.20	0.05	0.09	0.14
2	May 4 to 13	.21	.21	.21	.00	.00	.00	.00	.00	.00	.13	.17	.30
3	May 14 to 23	.08	.08	.08	.17	.42	.59	.04	.16	.20	.13	.19	.32
4	May 24 to June 2	.73	.83	1.56	.05	.45	1.23	.05	.23	.36	.07	1.43	3.10
5	June 3 to 12	.03	1.13	2.59	.01	2.01	2.79	.09	2.11	3.04	.25	.25	.25
6	June 13 to 22	.05	.30	.35	.02	1.46	3.01	.05	.55	1.68	.04	.05	.09
7	June 23 to July 2	.11	1.85	3.41	.08	.39	.73	.01	.60	.94	.02	1.29	1.47
8	July 3 to 12	.02	.88	.95	.08	1.44	2.31	.01	1.03	2.29	.21	1.22	3.26
9	July 13 to 22	.05	1.59	1.64	.01	2.00	4.44	.01	1.44	1.54	1.62	1.62	1.62
10	July 23 to August 1	.20	1.26	2.30	.04	.24	.47	.01	.11	.12	.26	.35	.61
11	August 2 to 11	.01	1.12	1.50	.01	.45	1.28	.03	1.10	2.50	.25	.85	1.40
12	August 12 to 21	.07	1.06	2.36	.02	.47	1.05	.08	.56	.95	1.70	1.70	1.70
13	August 22 to 31	.07	.18	.38	.04	.86	1.65	.01	2.52	3.84	.16	1.62	2.48
14	September 1 to 10	.24	.62	.86	.08	.08	.08	.01	.43	1.21	.18	1.50	2.01
	Total			19.44			19.78			18.87			18.75
	Longest period without rain.	7 days (July 20 to 26).			7 days (August 20 to 26).			9 days (July 20 to 28).			10 days (July 18 to 27).		

From the table it will be seen that at Goldsboro and Upper Marlboro the total rainfall between April 24 and September 10 was 19.44 inches and 19.78 inches, respectively, almost exactly equal amounts. At the other two stations the rainfall was also nearly the same and only about 1 inch less than at Goldsboro and at Marlboro, namely, 18.87 inches and 18.75 inches.

On the whole there was during the entire growing season an unusual uniformity in the rainfall conditions. Moreover, both the amounts and the distribution were such that there was little suffering on account of drought. It is probable that the soils were too wet at times for the best results, and yet they were never so wet as to produce serious injury. The season was backward at Janesville on account of cool weather.

RELATIVE AMOUNTS OF SUNSHINE AT THE FOUR STATIONS.

No self-recording instruments were used at either of the stations for obtaining the relative amounts of sunshine from day to day. A "judgment" record, however, was kept by an observer at each place on a percentage basis. Days of practically continuous clear sky, with the sun unobscured, were entered in the records as "sunshine 100 per cent." The sunshine on all other days was recorded as less than 100 per cent, ranging down to 0 for days when the clouds covered the entire sky continuously.

Daily Sunshine Records.

In the table which follows, the daily records for the four stations are given in 10-day periods from May 31 to October 17, or until all crops were harvested.

Field records of sunshine at Goldsboro, Upper Marlboro, Lancaster, and Janesville—1903.

Date.	Goldsboro.	Marlboro.	Lancaster.	Janesville.	Date.	Goldsboro.	Marlboro.	Lancaster.	Janesville.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
May 31	50	5	20	7	June 20	80	3	0	80
June 1	0	15	80	0	June 21	95	80	90	50
June 2	28	25	98	20	June 22	38	40	70	50
June 3	25	85	100	90	June 23	50	5	0	90
June 4	10	75	95	60	June 24	2	25	5	55
June 5	0	2	2	15	June 25	40	15	20	98
June 6	0	3	30	96	June 26	5	10	55	100
June 7	3	7	20	95	June 27	95	10	75	97
June 8	60	65	20	97	June 28	65	4	0	75
June 9	55	76	85	90	June 29	60	35	40	100
Sum	231	358	430	570	Sum	530	227	355	795
Average	23.1	35.8	43	57	Average	53	22.7	35.5	79.5
June 10	95	40	20	8	June 30	98	65	80	10
June 11	65	2	0	25	July 1	99	90	98	70
June 12	100	20	30	100	July 2	98	98	95	65
June 13	99	6	20	100	July 3	98	90	75	75
June 14	99	8	20	98	July 4	94	40	55	95
June 15	99	25	25	92	July 5	98	50	80	100
June 16	100	40	50	65	July 6	85	65	80	100
June 17	95	15	20	100	July 7	65	94	95	100
June 18	65	80	90	65	July 8	100	100	98	100
June 19	70	80	40	20	July 9	95	95	95	60
Sum	797	316	315	673	Sum	930	787	851	775
Average	79.7	31.6	31.5	67.3	Average	93	78.7	85.1	77.5

Field records of sunshine at Goldsboro, Upper Marlboro, Lancaster, and Janesville—1903—Continued.

Date.	Goldsboro.	Marlboro.	Lancaster.	Janesville.	Date.	Goldsboro.	Marlboro.	Lancaster.	Janesville.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
July 10	99	95	90	20	August 29	90	20	0	0
July 11	97	85	45	90	August 30	40	0	0	0
July 12	90	40	10	100	August 31	10	0	0	100
July 13	8	0	5	96	September 1	15	15	5	100
July 14	50	60	60	95	September 2	75	25	65	70
July 15	95	70	75	93	September 3	70	80	90	100
July 16	75	85	85	98	September 4	10	100	95	0
July 17	70	90	90	0	September 5	70	90	90	95
July 18	90	15	0	94	September 6	100	90	50	0
July 19	95	85	95	88	September 7	40	95	70	100
Sum	779	615	555	774	Sum	520	515	465	565
Average	77.9	61.5	55.5	77.4	Average	52	51.5	46.5	56.5
July 20	95	80	80	96	September 8	45	0	0	94
July 21	97	95	85	70	September 9	50	10	0	0
July 22	98	75	70	100	September 10	75	80	30	82
July 23	97	90	90	100	September 11	80	80	75	90
July 24	99	90	90	100	September 12	85	80	90	95
July 25	100	100	98	100	September 13		100	80	20
July 26	100	90	95	15	September 14		100	85	0
July 27	90	90	100	35	September 15		90	75	5
July 28	10	100	100	25	September 16		80	10	0
July 29	75	80	65	20	September 17		0	10	65
Sum	861	890	873	661	Sum	335	620	455	451
Average	86.1	89	87.3	66.1	Average	67	62	45.5	45.1
July 30	84	80	80	70	September 18		65	80	88
July 31	60	50	75	75	September 19		80	95	100
August 1	30	0	0	45	September 20		100	90	100
August 2	0	50	50	95	September 21		100	95	100
August 3	0	25	40	0	September 22		85	95	100
August 4	96	10	50	10	September 23		70	85	96
August 5	97	40	0	15	September 24		60	65	94
August 6	94	0	0	95	September 25		85	90	100
August 7	97	75	70	100	September 26		90	90	100
August 8	85	60	70	75	September 27			40	35
Sum	643	390	435	580	Sum		735	825	913
Average	64.3	39	43.5	58	Average		81.67	82.5	91.3
August 9	98	10	50	100	September 28			60	46
August 10	90	60	80	75	September 29			85	74
August 11	83	40	30	88	September 30			80	38
August 12	20	90	85	65	October 1			65	22
August 13	5	10	0	55	October 2			45	6
August 14	30	0	0	30	October 3			10	0
August 15	40	40	30	45	October 4			15	100
August 16	60	10	75	100	October 5			15	100
August 17	30	85	100	100	October 6			10	50
August 18	20	45	0	100	October 7			20	0
Sum	416	400	450	758	Sum			405	436
Average	41.6	40	45	75.8	Average			40.5	43.6
August 19	0	15	60	95	October 8			0	0
August 20	0	50	90	100	October 9			0	78
August 21	100	90	50	100	October 10			0	100
August 22	100	90	80	25	October 11			0	64
August 23	100	90	65	95	October 12			95	58
August 24	100	95	55	80	October 13			95	96
August 25	100	90	45	76	October 14			95	25
August 26	100	20	70	0	October 15			60	9
August 27	80	60	15	0	October 16			40	24
August 28	90	70	0	0	October 17			0	12
Sum	770	670	530	571	Sum			385	466
Average	77	67	53	57.1	Average			38.5	46.6

RELATIVE AMOUNTS OF SUNSHINE BY 10-DAY PERIODS.

Beginning with May 31, when the crops were fairly started at the 4 stations, the mean percentages of sunshine are presented in the table which follows.

Mean percentages of sunshine at the four stations in 10-day periods—1903.

Ten-day period.	Goldsboro, N.C.	Upper Marlboro, Md.	Lancaster, Pa.	Janesville, Wis.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
May 31 to June 9	23.1	35.8	43.0	57.0
June 10 to June 19	79.7	31.6	31.5	67.3
June 20 to June 29	53.0	22.7	35.5	79.5
June 30 to July 9	93.0	78.7	85.1	77.5
July 10 to July 19	77.9	61.5	55.5	77.4
July 20 to July 29	86.1	69.0	87.3	66.1
July 30 to August 8	64.3	39.0	43.5	58.0
August 9 to August 18	41.6	40.0	45.0	75.8
August 19 to August 28	77.0	67.0	53.0	57.0
August 29 to September 7	52.0	51.5	46.5	56.5
Average	64.77	49.78	52.59	67.21

The mean yields of corn in bushels per acre at the four stations were 37.58 at Goldsboro, 29.53 at Upper Marlboro, 53.78 at Lancaster, and 74.87 at Janesville.

It is, of course, to be understood that such results as these can not be regarded as expressing anything more than a very rough approximation to the true relative amounts of sunshine, and especially on account of having been made by 4 separate observers, whose judgments can hardly be presumed to be comparable, however relatively accurate they may have been from day to day. There is no evident connection between the percentages of sunshine shown in this table and the yields. It is true that the highest mean yield is associated with the highest percentage of sunshine, but, on the other hand, the sunshine at Goldsboro exceeded that at Lancaster, where the yield stands next to that of Janesville.

COMPARATIVE TEMPERATURES AT THE FOUR STATIONS.

Three series of temperature observations were made at each station: (1) Soil temperatures at 6, 12, 24, and 36 inches below the surface taken, with Greene mercurial soil thermometers, on the same dates, once weekly at the 4 stations and on each soil type; (2) thermograph records of the soil temperature at 1 foot below the surface on each of the 8 soil types; (3) thermograph records of the temperature of an unventilated metal shelter, having its base 3 feet above the surface of the ground in one of the cornfields under experiment.

Comparative Weekly Temperatures at Four Depths for Eight Soil Types.

To obtain these temperatures a set of portable soil thermometers, with stems of suitable lengths, were mounted in a brass tube carrying case provided with four lined pockets in which the respective thermometers could be carried. The thermometers were graduated to read to one-tenth of a degree F. To obtain the readings a set of wooden tubes 1.75 inches outside diameter, and with a bore large enough to permit the naked thermometers to be lowered through them, were sunk in the ground to the depth at which the temperatures were to be observed. At the lower end of the wooden cylinders three-

fourths of the tube was cut away, so as to expose the bulb of the thermometer to direct radiation from the soil when lowered so as to rest upon the soil at the bottom of the tube. In making the observations the 4 thermometers were lowered into place at the same time and allowed to remain there until they had become stationary. In all cases the observations were made between 1.30 and 4 p. m. In the tables which follow are given the records obtained at the 4 stations for each soil type:

Table giving the soil temperatures at depths of 6 inches, 12 inches, 24 inches, and 36 inches on the Norfolk sandy soil and Selma silt loam under corn at Goldsboro, N. C.—1903.

Date.	Norfolk sandy soil.						Selma silt loam.						Average of both soils.
	6 in.	12 in.	24 in.	36 in.	Sum.	Average.	6 in.	12 in.	24 in.	36 in.	Sum.	Average.	
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
April 25	58.0	56.2	56.5	57.0	227.7	56.92	58.1	56.5	56.5	57.0	228.1	57.02	56.98
May 2	66.7	61.7	60.7	59.8	248.9	62.23	64.5	60.1	59.3	58.6	242.5	60.63	61.43
May 9	64.0	63.4	63.0	62.3	252.7	63.18	63.4	62.1	61.0	59.8	246.3	61.58	62.38
May 16	76.7	70.7	65.5	64.0	276.9	69.23	75.0	69.0	64.6	61.6	270.2	67.55	68.39
May 23	79.5	75.5	71.0	68.0	294.0	73.50	78.1	74.5	68.9	66.7	288.2	72.05	72.78
May 30	79.5	74.0	71.0	69.4	293.9	73.48	78.1	73.5	69.8	67.6	289.0	72.25	72.86
June 6	72.0	71.1	69.0	68.1	280.2	70.05	69.8	69.2	67.4	66.1	272.5	68.13	69.09
June 13	72.7	69.4	70.0	69.9	282.0	70.50	70.1	68.0	69.0	68.4	275.5	68.88	69.69
June 20	82.2	76.6	73.4	71.1	303.3	75.83	77.8	73.4	70.0	68.1	289.3	72.33	74.08
June 27	80.7	75.5	74.0	72.7	302.9	75.73	79.4	74.0	72.3	70.5	296.2	74.05	74.89
July 8	89.4	81.2	77.5	74.9	323.0	80.75	84.6	78.8	74.4	72.5	310.3	77.58	79.17
July 11	91.6	83.0	79.3	76.9	330.8	82.70	87.5	81.0	76.9	74.0	319.4	79.80	81.30
July 18	85.0	77.6	76.5	75.7	314.8	78.70	80.5	74.7	75.3	74.0	304.5	76.10	77.40
July 25	89.7	82.5	80.2	78.9	331.3	82.82	86.5	80.3	77.7	75.5	320.0	80.00	81.41
August 1	84.5	80.5	79.2	78.3	322.5	80.62	82.0	79.1	77.8	75.7	314.6	78.65	79.63
August 8	86.0	81.2	79.6	78.2	325.0	81.25	84.1	77.7	75.8	74.2	311.8	77.95	79.60
August 15	80.0	78.5	78.4	77.6	314.5	78.62	81.3	78.4	77.3	75.8	312.8	78.20	78.41
August 22	81.4	77.7	76.4	76.3	311.8	77.95	81.0	76.2	75.7	75.0	307.9	76.97	77.46
August 29	90.8	85.0	81.7	79.6	337.1	84.27	90.3	83.0	79.3	76.8	329.4	82.35	83.31
September 5	83.0	77.2	77.6	78.0	315.8	78.95	81.8	76.3	76.8	76.3	311.2	77.80	78.38
September 12	87.7	81.6	79.5	78.7	327.5	81.87	85.4	79.1	77.9	76.4	318.8	79.70	80.47
September 19	67.0	68.0	74.5	76.4	285.9	71.47	68.5	70.0	75.1	75.5	289.1	72.27	71.87
Average	79.46	74.92	73.39	72.35	300.08	75.03	77.63	73.40	71.76	70.28	293.1	73.27	74.13

Soil temperatures at depths of 6 inches, 12 inches, 24 inches, and 36 inches on the Norfolk sand and sassafras sandy loam under corn at Upper Marlboro, Md.—1903.

Date.	Norfolk sand.						Sassafras sandy loam.						Average of both soils.
	6 in.	12 in.	24 in.	36 in.	Sum.	Average.	6 in.	12 in.	24 in.	36 in.	Sum.	Average.	
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
April 25	57.0	54.5	53.0	51.6	216.1	54.02	55.5	52.5	51.8	51.0	210.8	52.69	53.36
May 2	59.5	57.5	57.5	55.5	230.0	57.50	58.0	55.8	55.8	54.3	223.8	55.94	56.72
May 9	64.5	63.5	60.5	51.0	245.5	61.38	59.0	57.0	56.0	54.5	226.5	56.63	59.00
May 16	65.0	64.5	62.5	59.5	251.5	62.88	64.5	63.0	59.0	57.5	244.0	61.00	61.94
May 23	76.0	72.0	67.5	63.5	279.0	69.76	71.5	69.0	64.3	61.0	265.8	66.44	68.10
May 30	70.5	68.0	65.3	63.0	266.8	66.69	69.5	66.5	64.0	61.3	261.3	65.31	66.00
June 6	68.0	67.0	65.5	63.3	263.8	65.94	67.0	65.0	64.0	61.8	257.8	64.44	65.19
June 13	65.5	65.0	66.0	65.0	261.5	65.38	64.0	64.0	64.0	62.0	254.0	63.50	64.44
June 20	71.0	68.5	66.5	63.8	269.8	67.44	71.0	67.5	66.5	62.5	267.5	66.88	67.16
June 27	72.5	68.0	66.5	64.5	271.5	67.88	71.0	66.5	65.5	64.0	267.0	66.75	67.32
July 3	82.5	79.0	74.0	68.5	304.0	76.00	81.5	76.5	72.0	68.0	298.0	74.50	75.25
July 11	85.5	77.8	75.5	71.5	210.3	77.56	87.5	77.5	74.0	70.5	309.5	77.40	77.47
July 18	72.5	72.0	71.5	69.5	285.5	71.40	71.0	70.5	70.0	68.0	279.5	69.90	70.60
July 25	80.5	75.5	72.5	70.8	299.3	74.81	77.5	72.5	71.0	69.5	290.5	72.62	73.72
August 1	71.0	72.5	73.5	71.5	288.5	72.12	70.0	70.5	71.2	69.8	281.5	70.38	71.25
August 8	75.5	73.8	72.0	70.4	291.7	72.91	74.0	71.2	70.0	69.0	284.2	71.05	71.98
August 15	73.5	70.5	70.0	69.5	283.5	70.87	72.0	68.8	68.5	68.0	277.3	69.32	70.10
August 22	77.0	71.0	70.0	69.4	287.4	71.85	72.0	68.5	68.5	68.0	277.0	69.25	70.55
August 29	75.8	75.0	74.3	71.8	296.9	74.22	74.0	73.3	72.8	70.5	290.6	72.64	73.42
September 5	76.0	72.4	71.0	70.0	289.4	72.35	72.7	70.0	69.4	68.7	280.8	70.20	71.28
September 12	76.5	75.0	71.5	69.7	292.7	73.17	75.2	71.0	70.8	68.8	285.3	71.32	72.25
Average	72.18	69.67	67.93	65.68	275.5	68.91	70.40	67.50	66.15	64.22	268.2	67.06	67.96

Soil temperatures at depths of 6 inches, 12 inches, 24 inches, and 36 inches on the Hagerstown clay loam and Hagerstown loam under corn at Lancaster, Pa.—1903.

Date.	Hagerstown clay loam.						Hagerstown loam.						Average of both soils.
	6 in.	12 in.	24 in.	36 in.	Sum.	Average.	6 in.	12 in.	24 in.	36 in.	Sum.	Average.	
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
April 25	51.0	50.0	49.2	49.0	199.2	49.80	48.6	48.2	47.7	47.5	192.0	48.00	48.90
May 2	53.8	54.5	52.6	50.4	211.3	52.83	50.4	51.0	50.9	49.5	201.8	50.45	51.64
May 9	60.5	57.0	55.0	52.5	225.0	56.25	58.5	54.4	52.5	50.0	215.4	53.85	55.05
May 16	65.6	62.6	59.3	57.0	244.5	61.13	65.5	62.0	58.0	53.9	239.4	59.85	60.49
May 23	69.3	67.5	63.5	59.5	259.8	64.95	69.0	67.0	63.0	58.8	257.8	64.45	64.70
May 30	67.5	67.0	62.8	60.5	257.8	64.45	65.5	64.6	62.0	58.5	250.6	62.65	63.55
June 6	67.3	64.7	63.0	60.6	255.6	63.90	65.2	63.8	62.0	59.5	255.5	62.63	63.26
June 13	63.5	63.4	63.6	61.8	252.3	63.08	66.8	62.0	61.4	60.8	246.0	61.50	62.29
June 20	65.0	64.7	62.5	61.3	253.5	63.38	63.9	63.7	61.6	59.7	248.9	62.23	62.81
June 27	68.7	65.3	62.8	61.0	257.8	64.45	66.8	63.8	61.6	60.2	252.4	63.10	63.78
July 3	74.0	71.5	67.2	63.4	276.1	69.03	72.9	70.5	66.0	62.5	270.9	67.98	68.41
July 11	80.3	74.0	69.7	66.0	290.0	72.50	78.4	73.5	69.0	65.7	286.6	71.60	72.00
July 18	70.0	68.9	67.4	65.6	271.9	68.00	69.5	68.2	66.6	65.5	269.8	67.40	67.00
July 25	76.0	70.2	68.2	66.0	280.4	70.10	75.3	69.5	68.0	65.9	278.7	69.67	69.89
August 1	74.0	69.4	68.8	66.7	278.9	69.72	75.5	69.4	68.7	67.0	280.6	70.15	69.93
August 8	68.8	66.5	66.8	65.5	267.6	66.90	70.0	66.2	67.3	66.2	269.7	67.42	67.16
August 15	68.0	66.5	66.5	65.7	266.7	66.67	71.8	66.8	67.0	66.5	272.1	68.02	67.35
August 22	70.5	67.0	66.7	65.3	269.5	67.37	71.0	67.3	67.0	65.8	271.1	67.77	67.57
August 29	66.7	67.9	68.0	66.5	269.1	67.27	67.2	67.7	68.5	67.2	270.6	67.65	67.46
September 5	73.7	67.5	66.5	65.0	272.7	68.17	74.0	68.7	68.0	66.0	276.7	69.18	68.68
September 12	73.4	67.5	66.6	65.0	272.5	68.12	73.3	68.0	67.4	65.3	274.0	68.50	68.31
September 19	64.8	65.7	65.5	65.6	261.6	65.40	65.6	66.0	66.5	66.8	264.9	66.22	65.81
Average	67.84	65.42	63.74	61.77	258.85	64.70	67.49	64.65	63.21	61.31	256.66	64.10	64.37

Soil temperatures at depths of 6 inches, 12 inches, 24 inches, and 36 inches on the Janesville loam and Miami loam under corn at Janesville, Wis.—1903.

Date.	Janesville loam.						Miami loam.						Average of both soils.
	6 in.	12 in.	24 in.	36 in.	Sum.	Average.	6 in.	12 in.	24 in.	36 in.	Sum.	Average.	
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
April 25	47.6	45.8	44.5	43.2	181.1	45.25	49.0	45.7	44.1	42.9	181.7	45.42	45.35
May 2	45.2	45.0	44.9	44.2	179.3	44.83	45.4	45.1	45.7	44.9	181.1	45.28	45.05
May 9	52.4	49.5	47.2	45.5	194.6	48.65	55.6	50.5	48.7	45.6	200.4	50.10	49.38
May 16	61.0	56.7	52.5	49.3	219.5	54.88	60.8	57.0	53.5	50.6	221.9	55.48	55.18
May 23	64.4	61.2	56.4	52.4	234.4	58.60	64.0	61.6	57.0	53.8	236.4	59.10	58.85
May 30	55.4	57.2	57.0	54.5	224.1	56.03	55.3	60.4	57.6	54.6	227.9	56.98	56.50
June 6	61.0	57.5	55.0	53.1	226.6	56.65	62.6	59.0	56.1	54.5	232.2	58.05	57.35
June 13	64.0	54.5	55.9	57.8	232.2	58.05	62.0	56.0	56.9	57.9	232.8	58.20	58.13
June 20	68.1	63.5	59.7	57.8	249.1	62.28	69.5	63.8	61.2	58.9	253.4	63.35	62.82
June 27	72.4	66.5	60.9	57.7	257.5	64.38	74.5	67.4	63.0	60.0	264.9	66.23	65.30
July 3	77.2	72.0	65.3	61.0	275.5	68.88	76.2	72.3	67.0	63.4	278.9	69.73	69.31
July 11	77.8	71.5	66.6	63.5	279.4	69.80	80.5	72.5	68.6	65.6	287.2	71.80	70.80
July 18	69.5	67.0	65.0	63.2	264.7	66.20	71.6	68.3	66.5	65.2	271.6	67.90	67.00
July 25	72.7	69.6	65.8	63.5	271.6	67.90	78.9	71.9	69.3	65.9	286.0	71.50	69.70
August 1	65.4	65.0	64.9	63.6	258.9	64.95	68.5	66.7	66.5	65.6	267.3	66.82	65.88
August 8	66.5	66.0	64.5	63.2	260.2	65.05	67.6	66.0	65.7	65.0	264.2	66.05	65.55
August 15	64.5	64.0	62.7	62.0	253.2	63.30	66.0	65.4	64.4	63.6	259.4	64.85	64.07
August 22	69.6	66.5	63.8	62.5	262.4	65.60	71.2	67.8	65.6	64.5	269.1	67.27	66.44
August 29	66.0	65.5	64.5	63.5	259.5	64.87	65.0	65.5	65.0	64.7	260.2	65.05	64.96
September 5	65.1	63.5	62.5	62.0	253.1	63.28	64.9	63.3	63.2	63.0	254.4	63.60	63.44
September 12	67.5	64.5	62.2	61.6	255.8	63.95	69.4	66.2	63.7	63.4	262.7	65.67	64.81
September 19	55.8	56.2	59.5	60.6	232.1	58.02	57.9	56.7	59.0	61.0	234.6	58.65	58.34
Average	64.05	61.30	59.15	57.53	242.04	60.51	65.29	62.23	60.38	58.85	246.74	61.69	61.10

Mean Soil Temperatures at the Four Stations.

If a general average is obtained of all the observations made on the 2 soil types at each of the 4 stations, the results will appear as given in the next table.

Mean soil temperatures at 4 stations, between April 25 and September 12 to 19, with excess of temperature above that at Janesville, which was the lowest—1903.

Depth.	Goldsboro, N. C.	Upper Marlboro, Md.	Lancaster, Pa.	Janesville, Wis.
	°F.	°F.	°F.	°F.
Mean at 6 inches	78.55	71.29	67.67	64.67
Excess	13.88	6.62	3.00	....
Mean at 12 inches	74.16	68.59	65.04	61.77
Excess	12.39	6.82	3.27	....
Mean at 24 inches	72.58	67.04	63.48	59.77
Excess	12.81	7.27	3.71	....
Mean at 36 inches	71.32	64.95	61.54	58.19
Excess	13.13	6.76	3.35	....
Mean of all depths	74.31	67.96	64.37	61.10
Excess	13.21	6.86	3.27	....

It thus appears that the mean soil temperature at Janesville was in round numbers 3.3° F. lower than at Lancaster, 6.8° lower than at Upper Marlboro, and 13° lower than at Goldsboro.

Difference in Temperature of Soil Types in the same Locality.

At the same place there were differences in temperature in the soil types, which, although not large, are clearly characteristic of the types. In the next table are given the mean differences for all depths and for the 6-inch depth.

Temperature differences in soil types in the same locality—1903.

MEAN AT 6 INCHES.

Goldsboro, N. C.		Upper Marlboro, Md.		Lancaster, Pa.		Janesville, Wis.	
Soils.	Temperature.	Soils.	Temperature.	Soils.	Temperature.	Soils.	Temperature.
	°F.		°F.		°F.		°F.
N. S. S	79.46	N. S	72.18	H. C. L	67.84	M. L	65.29
S. S. L	77.63	S. S. L	70.40	H. L	67.49	J. L	64.05
Difference	1.83	Difference	1.78	Difference	.35	Difference	1.24

MEAN FOR ALL DEPTHS.

Goldsboro, N. C.		Upper Marlboro, Md.		Lancaster, Pa.		Janesville, Wis.	
N. S. S	75.03	N. S	68.91	H. C. L	64.70	M. L	61.69
S. S. L	73.27	S. S. L	67.06	H. L	64.37	J. L	60.51
Difference	1.76	Difference	1.85	Difference	.33	Difference	1.18

There is thus seen to be a small difference, which is evidently related to the relative water capacities of the soils compared.

Autographic Soil Temperature Records for Seven Soil Types.

At each of the stations a Richard thermograph was installed in such a manner that its bulb occupied a level 12 inches below the surface in each of the soil types, the site in each case being within the field of corn.

To install the thermographs in a manner which would leave them accessible for purposes of reading and changing the record sheets, an

excavation of proper depth was made and cased with wood. Each thermograph was provided with a galvanized-iron box, at one end of which was a rectangular projection into which the bulb of the thermograph could extend, its dimensions being such as to receive it readily. The metal box for the thermograph was placed against the south end of the excavation with its extension reaching out into the undisturbed soil, the soil having been cut away to such an extent as to receive the extension, leaving its walls in contact with the undisturbed soil. To cover the chamber in which the thermograph was placed, a flanged lid was provided, which extended downward into the chamber to such an extent as to permit it to carry a layer of soil 3 inches deep. This lid could be set aside when the instrument was to receive attention.

Before the thermographs were set in place they were compared with a Greene thermometer and set with it. At the close of the season a similar comparison was made. Through a misunderstanding the thermographs at Janesville were compared each week and set with a mercurial thermometer, but in the other cases the instruments were not altered during the season.

SUMMARY OF SOIL TEMPERATURE RECORDS.

The recorded temperatures have been tabulated for the even 2-hour intervals, beginning at 6 a. m., for each of the soils, and grouped in 10-day periods. A correction has been applied to the sums of the different periods, whose value was the difference between the thermograph and the mercurial thermometer at the close of the period. The original readings, however, stand in the tables (beginning on page 137) as taken from the thermograph records. In the following table are given the general averages as derived from all of the readings made for each of the soil types:

Mean 2-hourly temperature at 1 foot below the surface for 7 soil types, between about June 1 and September 20—1903.

Soil.	Hour of reading.											
	6.	8.	10.	Noon.	2.	4.	6.	8.	10.	M.	2.	4.
Norfolk sandy soil	76.47	76.07	75.97	76.26	77.23	78.59	79.26	79.41	79.07	78.51	77.86	77.23
Selma silt loam	77.17	76.51	76.36	76.44	76.82	77.48	78.21	78.66	78.69	78.43	78.05	77.61
Sassafras sandy loam	70.13	69.82	69.88	70.40	71.22	71.97	72.42	72.45	72.16	71.63	71.12	70.55
Hagerstown clay loam	65.39	65.12	64.89	64.86	65.06	65.47	65.90	66.17	66.30	66.22	65.98	65.74
Hagerstown loam	66.54	66.40	66.11	66.01	66.06	66.26	66.54	66.81	66.93	67.04	66.96	66.82
Janesville loam	63.71	63.43	63.38	63.33	63.44	63.72	64.05	64.34	64.34	64.44	64.28	64.02
Miami loam	65.35	65.05	65.01	65.06	65.17	65.54	65.92	66.22	66.31	66.21	66.01	65.71

From this table it is seen that the mean diurnal range of temperature has been 3.44° F. in the Norfolk sandy soil, 2.33° in the Selma silt loam, 2.93° in the Sassafras sandy loam, 1.44° in the Hagerstown clay loam, 1.03° in the Hagerstown loam, 1.11° in the Janesville loam, and 1.3° in the Miami loam. The greatest mean diurnal range has

therefore occurred at Goldsboro in the Norfolk sandy soil, and the least at Lancaster in the Hagerstown loam.

The times of minimum temperatures have occurred between 8 a. m. and 10 a. m. in the two Goldsboro types, in the Sassafras sandy loam and in the Miami loam, and their maxima have also occurred between 8 and 10 p. m. For the other 3 soils, which are heavier, the times of minima and maxima have been about two hours later, near noon and midnight, respectively. The exact times of the maxima and of the minima are not of course given by the data of the tables, but should be obtained by direct readings from the record sheets.

The mean temperatures at 2-hour intervals, for 10-day periods, are given for each soil type in the next table.

Mean temperature of soils at 1 foot below the surface at 2-hour intervals for 10-day periods, 1903.

NORFOLK SANDY SOIL.

10-day period.	Hour of reading.											
	6.	8.	10.	Noon.	2.	4.	6.	8.	10.	M.	2.	4.
May 17 to May 26..........	71.77	71.02	70.84	71.48	72.81	74.76	75.84	76.23	75.77	75.09	74.12	73.20
May 26 to June 5..........	70.97	70.38	70.03	70.23	71.23	72.22	72.98	73.25	73.03	72.55	71.96	71.30
June 5 to June 15..........	70.52	70.07	69.94	70.55	71.42	72.51	73.24	73.38	73.10	72.40	71.80	71.16
June 15 to June 25..........	73.65	73.02	72.90	73.29	74.39	75.70	76.93	77.33	77.11	76.47	75.66	74.84
June 25 to July 5..........	76.50	76.17	76.18	76.53	78.02	79.38	80.17	80.21	79.80	79.12	78.46	77.80
July 5 to July 15..........	79.78	79.48	79.56	80.26	81.34	82.47	83.02	82.87	82.32	81.39	80.68	80.04
July 15 to July 18..........	75.86	75.70	75 90	76.60	77.80	78.70	78.77	78.53	78.07	77.50	76.85	76.35
August 1 to August 4......	79.45	78.85	78.70	78.50	78.95	80.97	81.20	81.33	81.07	80.80	80.30	79.93
August 4 to August 14.....	81.21	81.11	81.06	80.17	80.68	82.48	83.01	83.24	82.93	82.43	82.01	81.43
August 14 to August 24....	78.61	78.31	78.15	78.40	78.90	79.84	80.48	80.71	80.53	80.20	79.74	79.41
August 24 to August 31....	82.89	82.71	82.41	82.83	84.00	85.49	86.21	86.43	86.04	85.69	84.83	84.03
General average	76.47	76.07	75.97	76.26	77.23	78.59	79.26	79.41	79.07	78.51	77.86	77.23

SELMA SILT LOAM.

10-day period.	6.	8.	10.	Noon.	2.	4.	6.	8.	10.	M.	2.	4.
May 17 to May 26..........	72.63	71.69	70.84	70.82	71.25	72.26	73.26	74.10	74.24	73.90	73.48	72.95
May 26 to June 5..........	70.75	70.07	69.95	70.05	70.49	71.09	71.69	71.94	71.89	71.69	71.25	70.92
June 5 to June 8............	69.57	69.37	69.30	69.90	69.90	70.20	70.27	70.30	70.30	70.10	70.10	69.75
July 22 to July 25..........	80.80	80.30	79.85	80.27	80.33	80.93	81.77	82.50	82.60	82.27	81.80	81.13
July 25 to August 4........	80.92	80.49	80.33	80.23	80.57	81.21	81.84	82.26	82.30	82.07	81.67	81.24
August 4 to August 14.....	81.20	80.87	80.67	80.48	80.75	81.29	82.23	82.67	82.71	82.56	82.22	81.73
August 14 to August 24....	78.28	76.05	77.75	77.72	77.94	78.38	79.01	79.37	79.43	79.32	79.01	78.73
August 24 to September 3..	82.09	81.65	81.24	81.15	81.54	82.22	83.01	83.44	83.45	83.19	82.82	82.36
September 3 to September 13..........................	77.76	77.38	77.00	77.12	77.68	78.53	79.35	79.78	79.75	79.51	78.90	78.88
September 13..............	77.70	77.20	76.70	76.70	77.70	78.70	79.70	80.20	80.20	79.70	79.20	78.40
General average	77.17	76.51	76.36	76.44	76.82	77.48	78.21	78.66	78.69	78.43	78.05	77.61

SASSAFRAS SANDY LOAM.

10-day period.	6.	8.	10.	Noon.	2.	4.	6.	8.	10.	M.	2.	4.
June 15 to June 25..........	66.14	65.85	66.17	66.73	67.58	68.41	68.76	68.65	68.34	67.82	67.16	66.55
June 25 to July 5..........	70.04	69.75	69.76	70.40	71.41	72.31	72.87	73.01	72.71	72.18	71.70	71.17
July 5 to July 15............	72.21	71.95	72.19	73.10	74.04	74.98	75.30	75.25	74.64	73.83	73.16	72.46
July 15 to July 25..........	69.84	69.55	69.60	70.24	71.12	71.83	72.32	72.48	72.32	71.80	71.33	70.67
July 25 to August 4........	71.98	71.72	71.78	72.31	73.12	73.77	74.21	74.19	73.93	73.42	72.85	72.40
August 4 to August 14.....	70.66	70.40	70.41	70.76	71.43	72.08	72.37	72.40	72.16	71.73	71.88	70.81
August 14 to August 24....	68.89	68.51	68.46	68.87	69.68	70.28	70.90	71.08	70.93	70.48	69.97	69.52
August 24 to September 3..	71.77	71.52	71.50	71.74	72.20	72.77	73.18	73.27	73.14	72.70	72.30	71.90
September 3 to September 13..........................	68.89	68.53	68.48	68.88	69.72	70.52	71.03	71.08	70.89	70.47	69.75	69.53
September 13 to September 20..................	70.92	70.37	70.43	70.96	71.92	72.73	73.26	73.13	72.56	71.87	71.12	70.45
General average	70.13	69.82	69.88	70.40	71.22	71.97	72.42	72.45	72.16	71.63	71.12	70.55

Mean temperature of soils at 1 foot below the surface at 2-hour intervals for 10-day periods, 1903—Continued.

HAGERSTOWN CLAY LOAM.

10-day period.	Hour of reading.											
	6.	8.	10.	Noon.	2.	4.	6.	8.	10.	M.	2.	4.
June 1 to June 5	63.23	63.18	63.10	63.39	63.95	64.70	65.23	65.70	65.78	65.60	65.48	65.13
June 5 to June 15	63.94	63.62	63.20	63.12	63.19	63.41	63.68	63.89	64.00	63.83	63.54	63.34
June 15 to June 25	60.35	59.95	59.85	59.75	59.87	60.18	60.59	60.89	61.12	61.11	60.99	60.84
June 25 to July 5	64.09	63.91	63.52	63.72	63.95	64.46	65.02	65.48	65.69	65.69	65.43	65.24
July 5 to July 15	70.16	69.67	69.44	69.42	69.75	70.32	70.91	71.20	71.23	71.06	70.74	70.36
July 15 to July 25	67.02	66.75	66.51	66.43	66.68	67.07	67.57	67.92	68.16	68.11	67.84	67.53
July 25 to August 4	67.57	67.57	67.36	67.29	67.44	67.86	68.32	68.58	68.71	68.63	68.36	68.14
August 4 to August 14	66.23	66.01	65.83	65.73	65.84	66.08	66.49	66.74	66.84	66.80	66.64	66.42
August 14 to August 18	65.62	65.34	65.08	65.00	65.14	65.48	65.70	65.98	66.05	66.03	65.83	65.73
August 24 to September 3	66.89	66.59	66.36	66.27	66.37	66.60	66.92	67.10	67.14	67.10	66.92	66.72
September 3 to September 13	64.62	64.25	64.12	64.01	64.15	64.52	64.98	65.27	65.38	65.34	65.11	64.86
September 13 to September 21	64.90	64.59	64.30	64.23	64.40	64.90	65.35	65.34	65.48	65.28	64.91	64.54
General average	65.39	65.12	64.89	64.86	65.06	65.47	65.90	66.17	66.30	66.22	65.98	65.74

HAGERSTOWN LOAM.

10-day period.	6.	8.	10.	Noon.	2.	4.	6.	8.	10.	M.	2.	4.
June 1 to June 5	63.13	62.90	62.20	61.90	62.03	62.40	62.85	63.40	63.75	63.90	63.89	63.83
June 5 to June 15	64.88	64.66	64.49	64.33	64.31	64.42	64.59	64.73	64.82	64.84	64.75	64.62
June 15 to June 25	62.54	62.40	62.26	62.08	62.06	62.18	62.43	62.66	62.79	62.90	62.89	62.78
June 25 to July 5	65.17	65.00	64.36	64.83	65.02	65.28	65.63	65.92	66.09	66.22	66.21	66.13
July 5 to July 15	71.22	71.06	70.73	70.58	70.72	71.08	71.39	71.65	71.85	71.86	71.60	71.42
July 15 to July 25	68.57	68.39	68.15	68.02	68.10	68.26	68.56	68.84	69.09	69.16	69.05	68.85
July 25 to August 4	70.13	69.85	69.47	69.29	69.35	69.58	69.92	70.27	70.50	70.59	70.51	70.32
August 4 to August 14	67.47	67.29	67.11	67.01	66.99	67.11	67.36	67.59	67.76	67.84	67.76	67.61
August 14 to August 24	66.70	66.43	66.22	66.10	66.17	66.36	66.66	66.98	67.13	67.20	67.11	66.96
August 24 to September 1	67.53	67.96	67.83	67.69	67.60	67.66	67.77	67.89	67.90	67.89	67.80	67.67
September 1 to September 7	......	......	......	......	......	......	......	......	......	......	......	......
September 7 to September 13	64.04	64.02	63.92	63.85	63.98	64.20	64.47	64.70	64.35	64.95	64.95	64.92
September 13 to September 20	67.11	66.85	66.60	66.41	66.40	66.60	66.86	67.05	67.13	67.09	67.05	66.67
General average	66.54	66.40	66.11	66.01	66.06	66.26	66.54	66.81	66.93	67.04	66.96	66.82

JANESVILLE LOAM.

10-day period.	6.	8.	10.	Noon.	2.	4.	6.	8.	10.	M.	2.	4.
June 8 to June 15	57.88	57.37	57.79	57.59	57.61	58.07	58.56	59.07	57.86	59.29	59.10	58.80
June 15 to June 25	61.97	61.51	61.39	61.29	61.54	61.96	62.49	62.88	63.05	62.96	62.73	62.39
June 25 to July 5	63.22	62.73	62.46	62.50	62.79	63.26	63.80	64.19	64.36	64.34	64.15	63.82
July 5 to July 15	63.70	63.62	63.41	63.34	63.51	63.95	64.30	64.73	64.82	64.74	64.44	64.17
July 15 to July 25	63.11	62.75	62.49	62.43	62.49	62.74	63.11	63.45	63.68	63.73	63.59	63.35
July 25 to August 4	65.64	65.57	65.80	65.77	65.90	66.17	66.45	66.66	66.78	66.74	66.54	66.18
August 4 to August 14	63.91	63.59	63.04	62.83	62.91	63.10	63.46	63.67	63.74	63.74	63.53	63.26
August 14 to August 24	66.36	66.13	67.16	67.13	67.17	67.47	67.69	67.99	68.21	68.29	68.26	68.12
August 24 to September 3	66.95	66.81	66.26	66.12	66.10	66.20	66.34	66.45	66.47	66.44	66.30	66.11
September 3 to September 13	64.37	64.24	64.18	64.44	64.53	64.65	64.82	64.98	65.12	65.11	65.09	64.92
September 13 to September 21	63.70	63.44	63.25	63.14	63.28	63.39	63.50	63.64	63.60	63.51	63.32	63.11
General average	63.71	63.43	63.38	63.33	63.44	63.72	64.05	64.34	64.34	64.44	64.28	64.02

MIAMI LOAM.

10-day period.	6.	8.	10.	Noon.	2.	4.	6.	8.	10.	M.	2.	4.
June 8 to June 15	56.13	55.75	55.30	56.09	56.09	56.40	56.89	57.22	57.46	57.47	57.23	57.07
June 15 to June 25	59.45	59.10	59.46	59.14	59.23	59.66	60.14	60.65	60.84	60.77	60.55	60.25
June 25 to July 5	65.16	64.91	64.66	64.82	65.18	65.65	66.21	66.54	66.63	66.41	66.24	65.89
July 5 to July 15	65.43	65.05	65.23	65.08	65.36	65.72	66.27	66.68	66.75	66.60	66.33	65.97
July 15 to July 25	66.85	66.40	66.34	66.39	66.57	66.94	67.54	67.97	68.11	68.04	67.81	67.51
July 25 to August 4	68.71	68.38	68.19	68.21	68.44	68.72	69.00	69.40	69.49	69.47	69.21	68.97
August 4 to August 10	......	......	......	......	......	......	......	......	......	......	......	......
August 10 to August 14	67.50	67.27	67.58	67.45	67.65	67.93	68.32	68.55	68.60	68.45	68.20	67.38
August 14 to August 24	70.47	70.18	70.35	70.40	70.63	71.01	71.35	71.61	71.72	71.66	71.51	71.32
August 24 to September 3	70.18	69.97	69.44	69.47	69.46	69.60	69.71	69.83	69.84	69.82	69.62	69.44
September 3 to September 13	65.06	64.81	64.94	64.95	65.06	65.36	65.60	65.84	65.94	65.85	65.72	65.57
September 13 to September 21	63.94	63.69	63.64	63.61	63.83	64.00	64.13	64.10	64.03	63.75	63.65	63.45
General average	65.35	65.05	65.01	65.06	65.17	65.54	65.92	66.22	66.31	66.21	66.01	65.71

SOIL TEMPERATURE RECORDS IN DETAIL.

In the next series of tables there are given the full sets of readings for the different soil types. The absence of records for the Norfolk sand is due to the fact that the instrument was injured and no records, except early in the season, were obtained.

Readings of the soil thermograph at the even 2-hour intervals, beginning at 6 a. m., under corn on the Norfolk sandy soil 1 foot below the surface, at Goldsboro, N. C., May 17 to August 30, arranged in 10-day periods—1903.

Date.	Hour of reading.											
	6.	8.	10.	Noon.	2.	4.	6.	8.	10.	M.	2.	4.
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
May 17	67.5	66.5	66.0	66.0	67.0	69.0	70.0	70.8	70.6	70.0	69.0	68.0
May 18	67.0	67.0	66.3	67.0	68.5	70.5	72.5	73.0	73.0	72.0	71.0	70.0
May 19	69.0	68.5	68.0	68.5	70.0	72.5	73.5	74.2	74.0	73.5	72.5	71.5
May 20	70.5	70.0	70.0	70.5	72.0	73.5	75.0	75.5	75.0	75.0	74.0	73.0
May 21	72.2	71.4	71.0	72.0	73.5	75.0	76.5	76.5	76.0	75.5	75.0	74.0
May 22	73.0	72.5	72.6	73.2	75.0	76.7	78.0	78.5	78.0	77.5	76.5	76.0
May 23	75.5	74.5	74.7	75.6	77.0	78.3	79.5	80.0	79.5	78.5	77.0	76.0
May 24	75.0	74.0	74.0	74.5	76.5	78.5	80.0	80.0	79.0	77.5	76.5	75.5
May 25	74.5	73.0	73.2	73.2	74.0	75.0	75.8	75.8	75.0	74.5	73.8	73.0
Sum	644.2	637.4	635.8	640.5	653.5	669.0	680.8	684.3	680.1	674.0	665.3	657.0
Corrected sum[a]	646.0	639.2	637.6	642 3	655.3	670.8	682.6	686.1	681.9	675.8	667.1	658.8
Average	71.77	71.02	70.84	71.48	72.81	74.76	75.84	76.23	75.77	75.09	74.12	73.20
May 26	72.0	71.5	71.0	70.5	71.0	72.0	72.5	73.0	73.0	72.5	72.0	71.5
May 27	71.0	70.8	70.8	71.2	72.5	73.5	74.2	74.5	74.2	73.5	73.0	72.0
May 28	71.7	71.0	70.5	70.0	72.0	73.0	74.5	75.0	75.0	74.5	73.8	73.0
May 29	72.5	72.0	72.0	72.0	72.8	74.0	74.8	75.0	74.0	74.2	73.8	72.8
May 30	72.0	71.5	71.5	72.0	73.5	75.5	77.0	77.7	77.6	77.0	76.0	75.0
May 31	74.0	73.5	73.0	73.5	75.0	76.0	77.0	76.5	76.0	75.0	74.0	73.5
June 1	72.5	71.0	69.5	69.8	69.5	69.2	69.0	69.0	68.8	68.0	67.5	67.2
June 2	67.0	66.5	66.0	66.5	67.5	68.2	68.8	69.0	68.7	68.3	68.0	67.5
June 3	67.0	66.5	66.5	66.8	67.5	68.8	69.5	69.8	70.0	69.5	69.0	68.5
June 4	68.0	67.5	67.5	68.0	69.0	70.0	70.5	71.0	71.0	71.0	70.5	70.0
Sum	707.7	701.8	698.3	700.3	710.3	720.2	727.8	730.5	728.3	723.5	717.6	711.0
Corrected sum[a]	709.7	703.8	700.3	702.3	712.3	722.2	729.8	732.5	730.3	725.5	719.6	713.0
Average	70.97	70.38	70.03	70.23	71.23	72.22	72.98	73.25	73.03	72.55	71.96	71.30
June 5	69.5	69.2	69.2	69.5	70.0	70.5	71.0	71.0	71.0	70.5	70.0	70.0
June 6	69.5	69.0	69.0	69.8	70.0	70.5	70.8	70.8	70.5	70.0	70.0	69.5
June 7	69.2	69.0	69.0	69.8	70.7	71.2	71.8	72.0	72.0	71.5	71.0	71.0
June 8	70.0	70.0	70.2	70.5	71.6	73.0	74.5	75.0	75.0	74.5	74.0	73.0
June 9	72.5	72.0	72.0	72.0	73.5	75.0	76.0	76.0	75.5	74.5	74.0	73.2
June 10	72.5	72.5	72.0	73.0	74.5	76.0	76.5	76.5	76.0	75.0	74.0	73.5
June 11	73.0	72.0	72.0	73.8	73.8	75.0	76.0	76.0	75.5	74.5	74.0	73.0
June 12	72.0	71.5	71.0	71.0	71.6	72.3	72.6	72.5	72.0	71.0	70.0	69.0
June 13	68.0	67.0	67.0	67.3	68.5	69.8	70.5	71.0	70.5	70.0	69.0	68.2
June 14	67.0	66.5	66.0	66.8	68.0	69.8	70.7	71.0	71.0	70.5	70.0	69.2
Sum	703.2	698 7	697.4	703.5	712.2	723.1	730.4	731.8	729.0	722.0	716.0	709.6
Corrected sum[a]	705.2	700.7	699.4	705.5	714.2	725.1	732.4	733.8	731.0	724.0	718.0	711.6
Average	70.52	70.07	69.94	70.55	71.42	72.51	73.24	73.38	73.10	72.40	71.80	71.16
June 15	68.5	68.0	68.7	68.8	70.0	71.0	73.0	73.5	73.2	72.5	71.5	70.5
June 16	69.6	68.7	68.3	69.0	70.2	72.0	73.8	74.5	74.2	73.5	72.5	71.0
June 17	70.5	70.0	70.0	71.0	72.5	74.5	76.5	77.0	77.0	76.0	75.0	74.2
June 18	73.5	72.8	72.2	72.6	73.6	75.0	76.7	77.0	76.7	75.6	75.0	74.0
June 19	73.0	72.2	72.3	73.0	75.0	77.0	78.2	78.5	78.0	77.5	77.0	76.0
June 20	75.2	75.0	75.0	75.5	76.5	77.2	78.0	78.0	78.0	78.0	77.1	76.7
June 21	76.0	75.5	75.5	76.0	77.5	79.0	80.2	80.7	80.5	80.0	79.0	78.0
June 22	77.2	76.5	76.0	76.0	76.8	77.8	78.0	78.0	77.5	76.8	76.0	75.5
June 23	75.0	74.0	74.0	74.0	74.8	76.0	77.5	79.0	79.0	78.3	77.5	76.7
June 24	76.0	75.5	75.0	75.0	75.0	75.5	75.4	75.1	75.0	74.5	74.0	73.8
Sum	734.5	728.2	727.0	730.9	741.9	755.0	767.3	771.3	769.1	762.7	754.6	746.4
Corrected sum[a]	736.5	730.2	729.0	732.9	743.9	757.0	769.3	773.3	771.1	764.7	756.6	748.4
Average	73.65	73.02	72.90	73.29	74.39	75.70	76.93	77.33	77.11	76.47	75.66	74.84

[a] These readings from soil thermographs were made from lower side of record mark: hence a correction at the rate of 0.2° daily is made to allow for one-half of width of mark.

Readings of the soil thermograph at the even 2-hour intervals, beginning at 6 a. m., under corn on the Norfolk sandy soil 1 foot below the surface, at Goldsboro, N. C., May 17 to August 30, arranged in 10-day periods—1903—Continued.

Date.	Hour of reading.											
	6.	8.	10.	Noon.	2.	4.	6.	8.	10.	M.	2.	4.
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
June 25	73.0	73.0	72.6	73.0	73.7	75.0	76.5	77.0	77.0	76.5	75.8	75.0
June 26	74.5	74.0	74.0	74.5	76.0	77.0	77.5	77.2	76.5	75.5	75.0	74.5
June 27	74.0	73.5	73.5	74.0	75.0	77.0	78.0	78.0	78.0	77.5	77.0	76.5
June 28	75.8	75.2	75.2	76.0	77.0	78.0	78.0	77.7	77.0	76.0	75.5	75.0
June 29	74.5	74.5	74.5	74.6	75.5	76.3	77.5	78.0	78.0	77.5	77.0	76.5
June 30	75.5	75.0	75.0	75.6	77.0	78.5	80.0	80.1	80.0	79.5	79.0	78.0
July 1	77.2	77.0	77.0	77.5	79.0	80.5	81.0	81.5	81.0	80.0	79.8	79.0
July 2	78.0	78.0	78.0	78.8	80.0	81.5	82.7	83.0	82.5	82.0	81.0	80.0
July 3	79.5	79.0	79.5	80.5	82.0	83.5	84.0	84.0	83.5	83.0	82.0	81.5
July 4	81.0	80.5	80.5	81.8	83.0	84.5	84.5	83.6	82.5	81.2	80.5	80.0
Sum	763.0	759.7	759.8	766.3	778.2	791.8	799.7	800.1	796.0	789.2	782.6	776.0
Corrected sum [a]	765.0	761.7	761.8	768.3	780.2	793.8	801.7	802.1	798.0	791.2	784.6	778.0
Average	76.50	76.17	76.18	76.83	78.02	79.38	80.17	80.21	79.80	79.12	78.46	77.80
July 5	79.0	79.0	79.0	80.0	80.8	82.0	82.0	82.0	81.6	81.0	80.2	80.0
July 6	80.0	79.5	79.0	79.0	79.8	81.0	82.2	82.2	81.6	80.7	80.0	79.5
July 7	79.0	78.2	78.0	78.5	79.0	80.0	81.0	81.0	80.8	80.0	79.2	78.6
July 8	77.8	77.0	77.0	77.8	79.0	81.0	82.5	82.5	81.8	80.5	80.0	79.0
July 9	78.0	77.5	77.8	79.0	80.5	82.5	83.5	83.5	83.0	82.0	81.3	80.5
July 10	80.0	79.8	80.0	81.5	82.8	84.0	84.5	84.5	84.0	83.0	82.3	81.5
July 11	81.0	81.0	81.8	83.0	85.0	86.0	86.0	85.5	85.0	84.0	83.3	82.5
July 12	82.0	82.0	83.0	84.0	85.0	85.2	85.0	84.7	83.8	83.2	82.8	82.0
July 13	82.0	82.0	81.5	81.0	81.5	82.0	82.0	81.0	80.0	79.0	78.2	77.8
July 14	77.0	76.8	76.5	76.8	78.0	79.0	79.5	79.8	79.0	78.5	77.5	77.0
Sum	795.8	792.8	793.6	800.6	811.4	822.7	828.2	826.7	821.2	811.9	804.8	798.4
Corrected sum [a]	797.8	794.8	795.6	802.6	813.4	824.7	830.2	828.7	823.2	813.9	806.8	800.4
Average	79.78	79.48	79.56	80.26	81.34	82.47	83.02	82.87	82.32	81.39	80.68	80.04
July 15	76.0	76.0	76.0	76.5	78.0	79.0	79.2	79.0	78.6	77.8	77.0	76.3
July 16	75.5	75.0	75.3	76.0	77.0	78.0	78.0	78.0	77.5	76.8	76.3	76.0
July 17	75.5	75.5	75.8	76.7	77.8	78.5	78.5	78.0	77.5	(b)	(b)	(b)
July 18 to 30 [b]	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
Sum	227.0	226.5	227.1	229.2	232.8	235.5	235.7	235.0	233.6	154.6	153.3	152.3
Corrected sum [a]	227.6	227.1	227.7	229.8	233.4	236.1	236.3	235.6	234.2	155.0	153.7	152.7
Average	75.86	75.70	75.90	76.60	77.80	78.70	78.77	78.53	78.07	77.50	76.85	76.35
August 1	(b)	(b)	(b)	(b)	(b)	81.5	81.0	81.0	80.5	80.0	79.0	78.5
August 2	78.0	77.3	77.0	76.6	76.7	77.0	77.2	77.3	77.0	77.0	76.8	76.7
August 3	76.5	76.0	76.0	76.0	76.8	77.8	78.8	79.1	79.1	78.8	78.5	78.0
Sum	154.5	153.3	153.0	152.6	153.5	236.3	237.0	237.4	236.6	235.8	234.8	233.2
Corrected sum [c]	158.9	157.7	157.4	157.0	157.9	242.9	243.6	244.0	243.2	242.4	240.9	239.8
Average	79.45	78.85	78.70	78.5	78.95	80.97	81.20	81.33	81.07	80.80	80.30	79.93
August 4	77.5	77.0	77.0	77.2	78.0	79.5	80.0	80.5	80.0	79.0	78.5	78.0
August 5	78.0	78.0	77.5	78.0	79.0	80.0	81.0	82.0	82.0	81.5	81.0	80.5
August 6	80.0	79.5	79.0	79.0	79.5	81.0	82.0	82.8	82.6	82.0	81.3	80.0
August 7	79.7	79.0	78.7	78.5	79.3	80.5	82.0	82.8	83.0	82.5	82.0	81.2
August 8	80.5	80.3	79.0	79.0	79.5	80.5	81.3	81.5	81.3	81.0	80.5	80.2
August 9	80.0	79.2	79.0	79.0	79.2	80.0	81.0	81.5	81.5	81.2	81.0	80.5
August 10	80.0	79.5	79.3	79.3	79.6	81.0	81.5	81.0	80.3	80.0	79.5	79.3
August 11	79.4	81.0	81.6	81.8	82.0	81.5	80.7	80.0	79.3	78.8	78.7	78.0
August 12	78.0	78.3	79.5	79.6	80.0	80.0	79.8	79.5	79.0	78.3	77.8	77.3
August 13	77.0	77.3	78.0	78.3	78.7	78.8	78.8	78.8	78.3	78.0	77.8	77.3
Sum	790.1	789.1	788.6	789.7	784.8	802.8	808.1	810.4	807.3	802.3	798.1	792.3
Corrected sum [c]	812.1	811.1	810.6	801.7	806.8	824.8	830.1	832.4	829.3	824.3	820.1	814.3
Average	81.21	81.11	81.06	80.17	80.68	82.48	83.01	83.24	82.93	82.43	82.01	81.43
August 14	77.0	77.0	77.8	78.3	77.7	80.0	80.5	80.8	80.3	80.0	79.7	79.2
August 15	78.5	78.0	77.8	77.8	78.0	79.3	79.3	79.3	79.0	78.8	78.3	77.8
August 16	77.2	77.0	76.8	76.7	77.0	78.0	79.0	79.3	79.2	78.8	78.2	77.7
August 17	77.0	77.0	76.0	76.0	76.5	77.0	77.6	78.0	77.8	77.3	77.0	76.3
August 18	76.0	75.3	75.0	75.0	76.0	76.5	76.8	77.0	77.0	76.8	76.2	75.8
August 19	75.6	75.2	75.0	75.0	75.3	75.8	76.5	76.6	76.5	76.3	76.0	76.0
August 20	75.7	75.5	75.3	75.7	76.0	76.3	76.8	77.0	77.0	76.7	76.2	76.8
August 21	75.3	75.0	74.8	75.0	76.0	77.0	77.7	78.0	77.5	77.0	76.5	76.0

[a] These readings from soil thermographs were made from lower side of record mark; hence a correction at the rate of 0.2° daily is made to allow for one-half of width of mark.

[b] The record was blank for July 18 to 30.

[c] From August 1 to 30 this thermograph made a reading 2° too low. The correction is, therefore, 2° daily with an additional correction of 0.2° daily on account of reading having been made from lower side of record mark.

Readings of the soil thermograph at the even 2-hour intervals, beginning at 6 a. m., under corn on the Norfolk sandy soil 1 foot below the surface, at Goldsboro, N. C., May 17 to August 30, arranged in 10-day periods—1903—Continued.

Date.	Hour of reading.											
	6.	8.	10.	Noon.	2.	4.	6.	8.	10.	M.	2.	4.
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
August 22	75.0	74.8	75.0	76.0	77.0	78.0	78.8	78.8	78.8	78.5	78.0	77.5
August 23	76.8	76.3	76.0	76.5	77.5	78.5	79.8	80.3	80.2	79.8	79.3	79.0
Sum	764.1	761.1	759.5	762.0	767.0	776.4	782.8	785.1	783.3	780.0	775.4	772.1
Corrected sum [a]	786.1	783.1	781.5	784.0	789.0	798.4	804.8	807.1	805.3	802.0	797.4	794.1
Average	78.61	78.31	78.15	78.40	78.90	79.84	80.48	80.71	80.53	80.20	79.74	79.41
August 24	78.0	78.0	77.8	77.8	78.5	80.0	81.0	81.3	81.0	80.5	80.0	79.0
August 25	78.5	78.0	78.0	78.5	79.5	81.0	81.3	82.3	82.5	82.3	81.8	81.0
August 26	80.3	80.0	79.7	80.0	81.3	83.0	84.0	84.5	84.2	84.0	83.0	82.5
August 27	82.0	81.5	81.0	81.5	82.5	84.0	84.8	84.5	83.7	83.0	82.0	81.5
August 28	81.0	80.5	80.7	81.5	83.0	84.5	85.2	85.2	84.7	84.0	83.3	82.3
August 29	82.0	82.0	82.0	82.5	84.0	85.5	86.3	86.5	86.0	86.6	85.0	84.0
August 30	83.0	82.6	82.3	82.6	83.8	85.0	85.5	85.3	84.8	84.0	83.3	82.5
August 31	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
Sum	564.8	562.6	561.5	564.4	572.6	583.0	588.1	589.6	586.9	584.4	578.4	572.8
Corrected sum [a]	580.2	577.0	576.9	579.8	588.0	598.4	603.5	605.0	602.3	599.8	593.8	588.2
Average	82.89	82.71	82.41	82.83	84.00	85.49	86.21	86.43	86.04	85.69	84.83	84.03

[a] From August 1 to 30 this thermograph made a reading 2° too low. The correction is, therefore, 2° daily with an additional correction of 0.2° daily on account of reading having been made from lower side of record mark.

[b] Record blank.

Readings of the soil thermograph at the even 2-hour intervals, beginning at 6 a. m., under corn on the Selma silt loam, 1 foot below the surface, at Goldsboro, N. C., May 18 to September 13, arranged in 10-day periods—1903.

Date.	Hour of reading.											
	6.	8.	10.	Noon	2.	4.	6.	8.	10.	M.	2.	4.
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
May 18	......	......	67.0	66.3	66.8	68.0	69.0	70.0	70.5	70.3	70.0	69.5
May 19	68.8	68.0	67.3	67.2	68.0	69.0	70.3	71.2	71.5	71.5	71.0	70.5
May 20	70.0	69.2	68.8	69.9	69.5	70.5	71.5	72.5	72.8	72.5	72.3	72.0
May 21	71.3	70.7	70.2	70.2	71.0	72.0	73.0	73.8	74.0	73.8	73.5	73.0
May 22	72.5	72.0	71.8	71.8	72.2	73.5	74.5	75.5	75.7	75.5	75.0	74.8
May 23	75.3	73.8	73.3	73.3	74.0	75.0	76.0	77.0	76.8	76.0	75.8	75.0
May 24	74.2	73.7	73.0	73.0	73.6	74.7	76.0	76.8	77.0	76.2	75.3	74.7
May 25	74.0	73.0	73.7	73.3	73.3	73.8	74.2	74.4	74.0	73.8	73.3	72.5
Sum	506.1	500.4	565.1	565.0	568.4	576.5	584.5	591.2	592.3	589.6	586.2	582.0
Corrected sum [a]	507.4	501.8	566.7	566.6	570.0	578.1	586.1	592.8	593.9	591.2	587.8	583.6
Average	72.63	71.69	70.84	70.82	71.25	72.26	73.26	74.10	74.24	73.90	73.48	72.95
May 26	72.0	71.2	70.8	70.5	70.8	71.2	71.6	71.8	71.8	71.6	71.2	71.0
May 27	70.8	70.5	70.5	70.8	71.3	71.8	72.3	72.5	72.3	72.0	71.6	71.0
May 28	70.7	70.3	70.0	70.2	70.7	71.3	72.0	72.8	72.8	72.8	72.2	72.0
May 29	71.6	71.0	71.0	71.0	71.3	72.2	73.0	73.2	73.2	73.0	72.5	72.0
May 30	71.6	71.0	71.0	71.2	72.0	73.3	74.5	75.0	75.0	74.8	74.5	74.0
May 31	73.3	72.8	72.5	72.6	73.5	74.0	74.8	74.8	74.3	74.0	73.2	72.8
June 1	72.0	70.0	70.0	69.8	70.0	69.8	69.7	69.5	69.3	69.0	68.5	68.0
June 2	68.0	67.3	67.2	67.2	67.8	68.3	68.7	68.8	68.8	68.5	68.0	67.8
June 3	67.5	67.0	67.0	67.2	67.8	68.0	68.8	69.0	69.2	69.0	68.8	68.8
June 4	68.0	67.6	67.5	68.0	68.5	69.0	69.5	70.0	70.2	70.2	70.0	69.8
Sum	705.5	698.7	697.5	698.5	702.9	708.9	714.9	717.4	716.9	714.9	710.5	707.2
Corrected sum [a]	707.5	700.7	699.5	700.5	704.9	710.9	716.9	719.4	718.9	716.9	712.5	709.2
Average	70.75	70.07	69.95	70.05	70.49	71.09	71.69	71.94	71.89	71.69	71.25	70.92
June 5	69.5	69.2	69.0	69.3	69.6	70.0	70.2	70.3	70.3	70.0	70.0	69.6
June 6	69.3	69.0	69.0	69.3	69.5	70.0	70.0	70.0	70.0	69.8	69.8	69.5
June 7	69.3	69.3	69.3	69.5	70.0	70.0	70.0	70.0	70.0	(b)	(b)	(b)
June 8 to 14	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
Sum	208.1	207.5	207.3	209.1	209.1	210.0	210.2	210.3	210.3	139.8	139.8	139.1
Corrected sum [a]	208.7	208.1	207.9	209.7	209.7	210.6	210.8	210.9	210.9	140.2	140.2	139.5
Average	69.57	69.37	69.30	69.90	69.90	70.20	70.27	70.30	70.30	70.10	70.10	69.75

[a] Correction at the rate of 0.2° daily on account of readings having been made from lower side of record mark.

[b] For June 15 to July 21 the record was blank.

Readings of the soil thermograph at the even 2-hour intervals, beginning at 6 a. m., under corn on the Selma silt loam, 1 foot below the surface, at Goldsboro, N. C., May 18 to September 13, arranged in 10-day periods—1903—Continued.

Date,	Hour of reading.											
	6.	8.	10.	Noon	2.	4.	6.	8.	10.	M.	2.	4.
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
June 15 to July 21	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
July 22	......	......	......	82.0	81.7	82.0	83.0	83.7	84.0	83.7	83.3	83.0
July 23	82.5	82.0	81.8	81.8	82.0	82.7	83.5	84.0	84.0	83.5	83.0	82.0
July 24	81.5	81.0	80.3	80.2	80.5	81.3	82.0	83.0	83.0	82.8	82.3	81.6
Sum	164.0	163.0	162.1	244.0	244.2	246.0	248.5	250.7	251.0	250.0	248.6	246.6
Corrected sum b	161.6	160.6	159.7	240.8	241.0	242.8	245.3	247.5	247.8	246.8	245.4	243.4
Average	80.80	80.80	79.85	80.27	80.33	80.93	81.77	82.50	82.60	82.27	81.80	81.13
July 25	81.0	80.5	80.0	80.0	80.8	81.5	82.5	83.0	83.0	83.0	82.5	82.0
July 26	81.3	81.0	80.5	80.5	81.0	82.0	83.0	83.5	84.0	83.8	83.5	83.0
July 27	82.5	82.0	84.0	83.3	83.8	84.5	85.2	85.8	85.8	85.3	85.0	84.3
July 28	84.0	83.0	82.0	82.0	82.0	82.3	82.8	83.0	83.0	82.8	82.5	82.0
July 29	81.8	81.3	81.0	81.0	81.3	82.0	83.0	84.0	84.3	84.2	84.0	83.6
July 30	83.0	82.6	82.2	82.2	82.8	83.8	84.7	85.3	85.3	85.0	84.0	83.3
July 31	83.0	82.5	82.0	80.0	82.3	83.0	83.5	83.5	83.2	82.8	82.2	81.8
August 1	81.3	81.0	80.8	80.8	81.0	81.8	82.0	82.0	81.8	81.3	81.0	80.8
August 2	80.3	80.0	79.8	79.5	79.5	79.5	79.7	79.8	79.8	79.7	79.3	79.2
August 3	79.0	79.0	79.0	79.0	79.2	79.7	80.0	80.7	80.8	80.8	80.7	80.3
Sum	817.2	812.9	811.3	810.3	813.7	820.1	826.4	830.6	831.0	828.7	824.7	820.4
Corrected sum b	809.2	804.9	803.3	802.3	805.7	812.1	818.4	822.6	823.0	820.7	816.7	812.4
Average	80.92	80.49	80.33	80.23	80.57	81.21	81.84	82.26	82.30	82.07	81.67	81.24
August 4	80.2	80.0	79.6	79.5	79.8	80.3	81.3	82.0	82.0	82.0	81.7	81.3
August 5	81.0	80.5	80.3	80.0	80.5	81.3	82.8	83.8	84.0	84.0	83.8	83.2
August 6	83.0	82.0	81.8	81.8	82.2	83.2	84.2	84.6	84.5	84.0	83.2	83.0
August 7	82.0	81.5	81.2	81.2	81.5	81.3	83.5	84.0	84.3	84.2	84.0	83.2
August 8	82.0	82.0	81.8	81.8	82.0	82.8	83.2	83.3	83.3	83.0	82.8	82.3
August 9	82.0	81.8	81.5	81.5	81.7	82.2	83.3	83.7	84.0	83.8	83.5	83.0
August 10	83.0	82.8	83.0	82.8	83.0	83.5	84.6	85.5	85.7	85.6	85.3	84.8
August 11	84.2	84.0	83.5	83.2	83.5	84.0	84.6	84.8	84.3	84.0	83.5	83.0
August 12	82.0	81.8	81.5	81.0	81.0	81.6	81.8	82.0	82.0	82.0	81.7	81.3
August 13	80.6	80.3	80.0	80.0	80.3	80.7	81.0	81.0	81.0	81.0	80.7	80.2
Sum	820.0	816.7	814.2	812.8	815.5	820.9	830.3	834.7	835.1	833.6	830.2	825.3
Corrected sum b	812.0	808.7	806.2	804.8	807.5	812.9	822.3	826.7	827.1	825.6	822.2	817.3
Average	81.20	80.87	80.62	80.48	80.75	81.29	82.23	82.67	82.71	82.56	82.22	81.73
August 14	80.0	80.0	79.6	79.7	80.0	80.6	81.5	81.7	81.8	81.8	81.7	81.5
August 15	81.0	80.7	80.6	80.5	80.5	80.7	81.0	81.3	81.3	81.0	80.7	80.5
August 16	80.0	80.0	79.7	79.7	80.0	80.5	81.0	81.2	81.2	81.0	80.5	80.2
August 17	80.0	79.0	78.0	78.0	78.0	78.0	78.8	79.0	79.2	79.2	79.0	78.6
August 18	78.3	78.0	78.0	77.5	77.7	78.0	78.5	79.0	79.0	79.0	78.8	78.3
August 19	78.0	78.0	77.8	77.8	77.8	78.0	78.5	78.8	79.0	79.0	78.8	78.7
August 20	78.5	78.3	78.0	78.0	78.2	78.7	79.0	79.0	79.0	79.0	79.0	78.7
August 21	78.0	78.0	77.5	77.6	77.9	78.5	79.0	79.7	79.7	79.5	79.0	79.0
August 22	78.0	77.5	77.5	77.5	78.0	78.8	79.8	80.2	80.3	80.0	80.0	79.5
August 23	79.0	79.0	78.8	78.9	79.3	80.0	81.0	81.8	81.8	81.7	81.5	81.3
Sum	790.8	788.5	785.5	785.2	787.4	791.8	798.1	801.7	802.3	801.2	799.0	795.3
Corrected sum b	782.8	780.5	777.5	777.2	779.4	783.8	790.1	793.7	794.3	793.2	791.0	787.3
Average	78.28	78.05	77.75	77.72	77.94	78.38	79.01	79.37	79.43	79.32	79.10	78.73
August 24	80.9	80.0	80.0	80.0	80.5	81.0	82.0	82.8	83.0	82.7	82.5	82.0
August 25	81.5	81.0	80.5	80.5	81.0	81.8	83.0	83.9	84.0	84.0	84.0	83.5
August 26	83.0	82.5	82.5	82.5	83.0	84.0	85.0	85.6	85.8	85.7	85.2	85.0
August 27	84.5	84.0	83.5	83.7	84.0	85.0	85.8	86.0	85.6	85.0	84.5	84.0
August 28	83.5	83.2	83.0	83.0	83.7	84.8	86.0	86.4	86.5	86.0	86.0	85.5
August 29	85.0	84.3	84.0	84.2	85.0	86.0	87.0	87.2	87.2	87.0	86.5	86.0
August 30	85.5	85.0	84.6	84.6	85.0	85.4	86.0	86.3	86.2	86.0	85.3	84.6
August 31	84.0	84.0	82.8	82.0	82.0	82.2	82.5	83.0	83.0	83.0	82.5	82.0
September 1	81.5	81.0	80.5	80.0	80.0	80.5	81.0	81.2	81.2	81.0	80.5	80.0
September 2	79.5	79.5	79.0	79.0	79.2	79.5	79.8	80.0	80.0	79.5	79.2	79.0
Sum	828.9	824.5	820.4	819.5	823.4	830.2	838.1	842.4	842.5	839.9	836.2	831.6
Corrected sum b	820.9	816.5	812.4	811.5	815.4	822.2	830.1	834.4	834.5	831.9	828.2	823.6
Average	82.09	81.65	81.24	81.15	81.54	82.22	83.01	83.44	83.45	83.19	82.82	82.36
September 3	78.5	78.0	78.0	78.0	78.5	78.8	79.5	79.8	79.7	79.5	79.0	78.5
September 4	78.0	77.5	77.4	77.5	78.0	78.5	79.0	79.0	79.0	78.8	78.0	77.6
September 5	77.0	77.0	76.5	77.0	77.8	79.0	80.0	80.5	80.2	79.8	79.0	78.3

a For June 15 to July 21 the record was blank.

b From July 22 this thermograph gave a record of 1° too high. Hence correction made is 1° for each day less the correction of 0.2° for each day on account of readings having been made from lower side of record mark.

Readings of the soil thermograph at the even 2-hour intervals, beginning at 6 a. m., under corn on the Selma silt loam, 1 foot below the surface, at Goldsboro, N. C., May 18, to September 13, arranged in 10-day periods—1903—Continued.

Date.	Hour of reading.											
	6.	8.	10.	Noon	2.	4.	6.	8.	10.	M.	2.	4.
	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*
September 6	77.6	77.0	77.0	77.5	78.5	79.5	80.0	80.0	80.0	79.8	79.0	78.9
September 7	78.5	78.0	78.0	78.0	78.0	79.0	79.6	80.2	80.5	80.4	80.0	79.5
September 8	79.0	78.6	78.0	78.0	78.0	79.0	80.0	80.8	81.0	80.8	80.5	80.0
September 9	79.5	79.2	79.0	79.0	79.5	80.0	81.3	82.0	82.0	82.0	81.0	80.5
September 10	80.0	79.5	78.6	78.6	79.5	80.0	81.0	81.5	81.5	81.0	80.5	81.0
September 11	79.0	78.5	78.0	78.0	78.5	79.5	80.5	81.0	80.6	80.5	80.0	79.5
September 12	78.5	78.0	77.5	77.6	78.5	80.0	80.6	81.0	81.0	80.5	80.0	79.0
Sum	785.6	781.3	778.0	779.2	784.8	793.3	801.5	805.8	805.5	803.1	797.0	792.8
Corrected sum [a]	777.6	773.3	770.0	771.2	776.8	785.3	793.5	797.8	797.5	795.1	789.0	788.8
Average	77.76	77.33	77.00	77.12	77.68	78.53	79.35	79.78	79.75	79.51	78.90	78.88
September 13	78.5	78.0	77.5	77.5	78.5	79.5	80.5	81.0	81.0	80.5	80.0	79.2
Corrected [a]	77.7	77.2	76.7	76.7	77.7	78.7	79.7	80.2	80.2	79.7	79.2	78.4

[a] During this time this thermograph made a reading 1° too high. The correction is, therefore, 1° daily less the correction of 0.2° daily on account of readings having been made from lower side of record mark.

Readings of the soil thermograph at the even 2-hour intervals, beginning at 6 a. m., under corn on the Sassafras sandy loam 1 foot below the surface, at Upper Marlboro, Md., June 15 to September 20, arranged in 10-day periods—1903.

Date.	Hour of reading.											
	6.	8.	10.	Noon	2.	4.	6.	8.	10.	M.	2.	4.
	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*
June 15		61.0	61.0	61.0	61.5	62.0	62.6	62.6	62.0	61.7	61.0	60.7
June 16	60.5	61.0	62.5	64.0	65.0	66.0	66.0	65.5	65.0	64.5	64.0	63.5
June 17	63.5	63.5	63.5	64.0	65.0	66.0	66.0	66.0	65.8	65.5	65.0	64.8
June 18	64.0	63.8	64.0	65.0	66.0	67.0	68.0	68.0	67.8	67.0	66.0	65.0
June 19	64.5	64.5	65.0	66.0	67.2	68.5	69.0	69.0	68.8	68.0	67.5	67.0
June 20	66.5	66.5	66.8	67.0	67.0	67.8	68.0	68.0	68.0	67.5	66.8	66.0
June 21	65.5	65.5	65.8	66.3	67.0	67.5	68.0	67.8	67.0	66.5	65.5	64.5
June 22	64.0	64.0	64.5	65.0	66.5	67.5	67.5	67.0	66.5	66.0	65.0	64.5
June 23	64.3	64.2	64.0	64.0	64.8	65.0	65.5	65.6	65.5	65.0	65.0	64.8
June 24	64.5	64.5	64.6	65.0	65.8	66.8	67.0	67.0	67.0	66.5	65.8	65.5
Sum	577.3	638.5	641.7	647.3	655.8	664.1	667.6	666.5	663.4	658.2	651.6	646.3
Corrected sum [a]	595.3	658.5	661.7	667.3	675.8	684.1	687.6	686.5	683.4	678.2	671.6	665.5
Average	66.14	65.85	66.17	66.73	67.58	68.41	68.76	68.65	68.34	67.82	67.16	66.55
June 25	65.0	65.0	65.0	65.3	65.8	66.5	67.0	67.0	67.0	66.8	66.5	66.3
June 26	66.0	66.0	66.0	66.0	66.8	67.8	68.0	68.0	68.0	67.5	67.0	67.0
June 27	66.5	66.0	66.0	66.6	67.0	68.0	68.8	69.0	69.0	68.5	68.0	67.8
June 28	67.5	67.5	67.8	68.5	69.0	69.5	69.8	69.8	69.5	69.0	69.0	68.8
June 29	68.5	67.0	66.0	66.0	66.5	66.7	67.0	67.5	67.5	67.0	66.5	65.5
June 30	65.0	65.0	65.0	66.0	67.5	69.0	70.0	70.0	70.0	69.5	69.0	68.5
July 1	67.8	67.5	68.0	69.0	70.5	72.0	72.8	72.8	72.7	72.0	71.5	71.0
July 2	70.0	70.0	70.0	71.0	72.5	73.6	74.7	75.0	74.8	74.0	73.5	72.5
July 3	71.8	71.5	71.8	72.8	74.5	76.0	76.6	76.5	75.6	75.0	74.0	73.0
July 4	72.3	72.0	72.0	73.0	74.0	74.0	74.0	74.5	73.0	72.5	72.0	71.3
Sum	680.4	677.5	677.6	684.2	694.1	703.1	708.7	710.1	707.1	701.8	697.0	691.7
Corrected sum [a]	700.4	697.5	697.6	704.0	714.1	723.1	728.7	730.1	727.1	721.8	717.0	711.7
Average	70.04	69.75	69.76	70.40	71.41	72.31	72.87	73.01	72.71	72.18	71.70	71.17
July 5	71.0	70.5	70.5	71.0	72.5	73.0	73.3	73.2	72.8	72.0	71.5	71.0
July 6	70.5	70.3	70.5	72.5	72.0	72.8	73.0	73.0	72.8	72.0	71.0	70.0
July 7	69.0	68.8	68.8	69.5	71.0	72.0	73.0	73.0	72.5	71.5	70.5	69.5
July 8	68.8	68.8	69.0	70.0	71.8	73.0	73.6	73.8	73.0	72.5	72.0	71.0
July 9	70.3	70.3	70.6	72.0	73.0	75.0	75.5	75.5	75.0	74.0	73.0	72.0
July 10	71.5	71.0	71.5	72.3	73.8	75.0	75.8	75.8	75.2	74.5	73.8	73.0
July 11	72.3	72.0	72.5	73.5	74.8	76.0	76.0	75.7	74.5	73.5	72.7	72.0
July 12	71.2	71.0	71.2	72.5	73.0	73.0	72.5	72.0	71.3	71.0	70.3	70.0
July 13	69.5	69.0	69.5	69.5	69.5	70.0	70.0	70.0	69.3	69.0	68.8	68.3
July 14	68.0	67.8	67.8	68.2	69.0	70.0	70.3	70.5	70.0	69.3	68.0	67.8
Sum	702.1	699.5	701.9	711.0	720.4	729.8	733.0	732.5	726.4	718.3	711.6	704.6
Corrected sum [a]	722.1	719.5	721.9	731.0	740.4	749.8	753.0	752.5	746.4	738.3	731.6	724.6
Average	72.21	71.95	72.19	73.10	74.04	74.98	75.30	75.25	74.64	73.83	73.16	72.46

[a] Correction of 2° for each day on account of thermograph readings being that much too low.

Readings of the soil thermograph at the even 2-hour intervals, beginning at 6 a. m., under corn on the Sassafras sandy loam 1 foot below the surface, at Upper Marlboro, Md., June 15 to September 20, arranged in 10-day periods—1903—Continued.

Date.	Hour of reading.											
	6.	8.	10.	Noon.	2.	4.	6.	8.	10.	M.	2.	4.
	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*
July 15	67.0	66.8	66.8	67.0	67.8	68.0	68.2	68.0	67.5	67.0	66.2	65.5
July 16	65.0	64.3	64.3	65.0	66.3	67.3	68.0	68.0	68.0	67.5	67.0	66.0
July 17	65.3	65.0	65.3	66.3	67.5	68.5	69.0	69.2	69.0	68.5	68.0	67.8
July 18	67.5	67.3	67.2	67.2	67.5	68.0	68.5	69.0	69.2	69.0	68.8	68.0
July 19	67.7	67.3	67.4	67.8	68.3	69.0	69.6	69.8	69.7	69.0	68.6	68.0
July 20	67.5	68.5	68.0	68.8	70.0	70.8	71.3	71.3	71.0	70.7	70.0	69.3
July 21	68.7	68.0	68.0	68.8	69.5	70.3	71.0	71.3	71.0	70.6	70.2	69.8
July 22	69.2	69.0	69.5	70.3	71.5	72.3	72.8	73.0	72.8	72.2	72.0	71.3
July 23	70.8	70.0	70.0	70.7	71.3	71.8	72.0	72.2	72.0	71.5	71.0	70.2
July 24	69.7	69.3	69.5	70.5	71.5	72.3	72.8	73.0	73.0	72.0	71.5	70.8
Sum	678.4	675.5	676.0	682.4	691.2	698.3	703.2	704.8	703.2	698.0	693.3	686.7
Corrected sum [a]	698.4	695.5	696.0	702.4	711.2	718.3	723.2	724.8	723.2	718.0	713.3	706.7
Average	69.84	69.55	69.60	70.24	71.12	71.83	72.32	72.48	72.32	71.80	71.33	70.67
July 25	70.0	69.8	70.0	70.5	71.8	72.5	73.0	73.3	73.0	72.8	72.3	71.8
July 26	71.3	70.8	71.0	72.0	72.8	73.5	74.0	74.0	74.0	73.4	73.0	72.8
July 27	72.0	71.5	71.7	71.8	72.0	72.3	72.8	72.8	72.3	71.5	70.7	69.8
July 28	69.0	68.3	68.3	68.8	69.8	70.8	71.4	71.7	71.7	71.3	70.5	70.3
July 29	70.0	70.0	70.0	71.0	72.5	73.8	74.5	74.6	74.3	73.8	73.0	72.7
July 30	72.0	71.8	72.0	73.0	74.3	75.0	75.8	75.5	75.0	74.0	73.5	73.0
July 31	72.3	72.0	72.0	72.0	72.0	72.0	72.0	71.3	71.0	70.3	69.8	69.0
August 1	68.7	68.2	68.0	68.0	68.0	68.0	68.0	68.0	67.8	67.3	67.0	66.8
August 2	66.7	66.5	66.5	67.0	68.0	69.0	69.3	69.4	69.2	69.0	68.5	68.0
August 3	67.8	68.3	68.3	69.0	70.0	70.8	71.3	71.3	71.0	70.8	70.2	69.8
Sum	699.8	697.2	697.8	703.1	711.2	717.7	722.1	721.9	719.3	714.2	708.5	704.0
Corrected sum [a]	719.8	717.2	717.8	723.1	731.2	737.7	742.1	741.9	739.3	734.2	728.5	724.0
Average	71.98	71.72	71.78	72.31	73.12	73.77	74.21	74.19	73.93	73.42	72.85	72.40
August 4	69.3	69.0	69.0	69.0	69.3	69.4	69.5	69.6	69.5	69.3	69.0	68.8
August 5	68.6	68.5	68.8	69.5	70.8	71.5	72.0	72.0	71.7	71.0	70.5	70.0
August 6	69.8	69.5	69.3	69.2	69.3	69.8	70.2	70.3	70.2	70.0	69.5	69.0
August 7	68.5	68.0	68.0	68.8	69.5	70.0	70.0	69.5	68.8	68.0	67.0	66.0
August 8	65.3	65.0	65.3	66.3	67.5	68.8	68.5	68.5	68.3	68.0	67.8	67.8
August 9	67.5	67.5	67.5	68.0	68.8	69.8	70.4	70.5	70.4	70.0	69.5	69.0
August 10	68.7	69.0	69.0	69.3	70.3	71.3	72.0	72.3	72.2	72.0	71.5	71.0
August 11	70.8	70.5	70.5	70.5	71.0	71.2	71.5	71.7	71.5	71.0	70.7	70.2
August 12	69.8	69.0	69.0	69.3	70.0	71.0	71.3	71.3	71.0	70.0	69.5	69.0
August 13	68.3	68.0	67.7	67.7	67.8	68.0	68.3	68.3	68.0	68.0	67.8	67.3
Sum	686.6	684.0	684.1	687.6	694.3	700.8	703.7	704.0	701.6	697.3	692.8	688.1
Corrected sum [a]	706.6	704.0	704.1	707.6	714.3	720.8	723.7	724.0	721.6	717.3	712.8	708.1
Average	70.66	70.40	70.41	70.76	71.43	72.08	72.37	72.40	72.16	71.73	71.28	70.81
August 14	67.2	67.0	67.0	67.0	67.0	67.0	67.0	67.0	67.0	66.5	66.3	66.0
August 15	66.0	66.0	66.0	66.5	67.3	68.3	68.8	69.0	68.8	68.5	68.0	67.3
August 16	67.0	66.7	66.3	66.5	66.8	67.5	67.8	68.0	67.8	67.2	67.0	66.8
August 17	66.5	66.0	66.0	66.3	67.0	67.8	68.4	68.6	68.4	67.8	67.0	66.5
August 18	65.8	65.0	65.0	65.8	66.8	67.5	68.0	68.3	68.3	68.0	67.8	67.3
August 19	67.0	66.7	66.8	67.0	68.0	68.3	68.8	69.0	69.0	68.8	68.5	68.3
August 20	68.2	68.0	68.0	68.3	68.8	69.3	69.8	70.0	69.8	69.0	68.3	67.5
August 21	66.8	66.2	66.0	66.5	67.8	68.8	69.4	69.6	69.2	68.5	67.5	67.0
August 22	66.0	65.5	65.5	65.5	68.0	68.0	70.0	70.0	70.0	69.7	69.3	69.0
August 23	68.4	68.0	68.0	68.3	69.3	70.3	71.0	71.3	71.0	70.8	70.0	69.5
Sum	668.9	665.1	664.6	668.7	676.8	682.8	689.0	690.8	689.3	684.8	679.7	675.2
Corrected sum [a]	688.9	685.1	684.6	688.7	696.8	702.8	709.0	710.8	709.3	704.8	699.7	695.2
Average	68.89	68.51	68.46	68.87	69.68	70.28	70.90	71.08	70.93	70.48	69.97	69.52
August 24	69.0	68.5	(*b*)	(*b*)	(*b*)	(*b*)	(*b*)	(*b*)	(*b*)	(*b*)	(*b*)	(*b*)
August 25	(*b*)	70.3	70.3	71.0	72.0	73.5	74.5	75.0	75.0	74.8	74.0	73.8
August 26	73.0	72.8	72.5	73.0	73.8	74.5	75.0	75.0	75.0	74.6	74.0	73.8
August 27	73.3	73.0	72.8	72.8	73.0	73.3	73.5	73.3	73.0	72.5	72.0	71.8
August 28	71.5	71.3	71.3	71.7	72.8	73.8	74.3	74.3	73.8	73.0	72.5	72.0
August 29	71.8	71.3	71.0	71.0	71.2	71.3	71.5	71.3	71.0	70.5	70.0	69.0
August 30	68.7	68.0	68.0	68.0	68.0	68.0	68.0	68.0	68.0	68.0	67.8	67.8
August 31	67.5	67.5	67.3	67.5	67.5	67.5	67.5	67.5	67.5	67.0	67.0	67.0
September 1	66.6	66.5	66.3	66.2	66.5	67.0	67.5	68.0	68.0	67.7	67.3	67.0
September 2	66.5	66.0	66.0	66.5	67.0	68.0	68.8	69.0	69.0	68.6	68.0	67.7
Sum	627.9	695.2	625.5	627.7	631.8	636.9	640.6	641.4	640.3	636.7	632.6	629.9
Corrected sum [a]	645.9	715.2	643.5	645.7	649.8	654.9	658.6	659.4	658.3	654.7	650.6	647.9
Average	71.77	71.52	71.50	71.74	72.20	72.77	73.18	73.27	73.14	72.70	72.30	71.90

[a] Correction of 2° for each day on account of thermograph readings being that much too low.
[b] Record blank for August 24.

Readings of the soil thermograph at the even 2-hour intervals, beginning at 6 a.m., under corn on the Sassafras sandy loam 1 foot below the surface, at Upper Marlboro, Md., June 15 to September 20, arranged in 10-day periods—1903—Continued.

Date.	Hour of reading.											
	6.	8.	10.	Noon.	2.	4.	6.	8.	10.	M.	2.	4.
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
September 3	67.2	67.0	67.0	67.2	68.0	69.0	70.0	70.0	70.0	69.7	69.0	68.5
September 4	67.8	67.0	67.0	67.5	68.8	70.0	70.5	71.0	70.6	70.0	69.4	68.8
September 5	68.0	67.7	67.7	68.0	69.0	70.0	71.0	71.0	71.0	70.5	69.8	69.0
September 6	68.5	68.0	68.0	68.0	68.5	69.0	69.2	69.0	68.0	67.0	66.0	65.2
September 7	64.3	63.5	63.0	63.5	64.0	66.0	66.5	66.5	66.0	65.7	65.2	65.0
September 8	64.8	64.6	64.6	64.7	64.8	65.0	65.0	65.0	65.0	65.0	64.8	64.6
September 9	64.5	64.5	64.5	65.0	65.3	65.7	66.0	66.0	66.3	66.0	66.0	66.0
September 10	66.0	66.0	66.0	66.7	68.0	69.0	69.8	70.0	70.0	69.8	69.3	69.0
September 11	68.5	68.0	68.0	68.7	69.5	70.5	71.0	71.0	71.0	70.5	70.0	69.7
September 12	69.3	69.0	69.0	69.5	70.5	71.0	71.3	71.3	71.0	70.5	70.0	69.5
Sum	668.9	665.3	664.8	668.8	677.2	685.2	690.3	690.8	688.9	684.7	679.5	675.3
Corrected sum [a]	688.9	685.3	684.8	688.8	697.2	705.2	710.3	710.8	708.9	704.7	697.5	695.3
Average	68.89	68.53	68.48	68.88	69.72	70.52	71.03	71.08	70.89	70.47	69.75	69.53
September 13	69.0	68.5	68.3	69.0	70.3	71.3	72.0	72.0	71.8	71.2	70.8	70.0
September 14	69.5	69.0	70.0	70.3	71.3	72.3	73.0	73.0	72.5	72.0	71.5	71.0
September 15	70.3	70.0	70.0	70.4	71.5	72.3	73.0	73.0	72.5	72.0	71.2	70.8
September 16	70.5	70.0	70.0	71.0	72.0	73.0	74.0	74.0	73.7	73.2	73.0	72.7
September 17	72.4	72.0	72.0	72.0	72.5	73.0	73.0	72.5	71.5	70.3	69.2	68.2
September 18	67.2	66.2	66.0	66.2	66.8	67.0	67.0	66.6	65.8	64.8	63.8	62.8
September 19	62.0	61.3	61.2	62.0	63.0	64.0	64.3	64.3	63.7	63.0	62.0	61.3
September 20	70.5	70.0	70.0	70.8	72.0	73.0	73.8	73.8	73.0	72.5	71.5	70.8
Sum	551.4	547.0	547.5	551.7	559.4	565.9	570.1	569.2	564.5	559.0	553.0	547.6
Corrected sum [a]	567.4	563.0	563.5	567.7	575.4	581.9	586.1	585.2	580.5	575.0	569.0	563.6
Average	70.92	70.37	70.43	70.96	71.9	272.73	73.26	73.13	72.56	71.87	71.12	70.45

[a] Correction of 2° for each day on account of thermograph readings being that much too low.

Readings of the soil thermograph at even 2-hour intervals, beginning at 6 a. m., under corn on the Hagerstown clay loam 1 foot below the surface, at Lancaster, Pa., June 1 to September 20, arranged in 10-day periods—1903.

Date.	Hour of reading.											
	6.	8.	10.	Noon.	2.	4.	6.	8.	10.	M.	2.	4.
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
June 1	60.5	61.0	61.0	61.3	62.0	62.5	63.0	63.5	63.6	63.6	63.3	63.0
June 2	62.8	62.5	62.5	62.7	63.0	64.0	64.5	65.0	65.0	65.0	64.8	64.5
June 3	64.0	63.7	63.5	63.7	64.0	65.0	65.8	66.0	66.2	66.0	66.0	65.7
June 4	65.0	64.7	64.6	65.0	66.0	66.5	67.0	67.5	67.5	67.0	67.0	66.5
Sum	252.3	251.9	251.6	252.7	255.0	258.0	260.3	262.0	262.3	261.6	261.1	259.7
Corrected sum [a]	253.1	252.7	252.4	253.5	255.8	258.8	261.1	262.8	263.1	262.4	261.9	260.5
Average	63.28	63.18	63.10	63.39	63.95	64.70	65.28	65.70	65.78	65.60	65.48	65.13
June 5	66.0	65.5	65.0	65.0	65.0	65.0	65.0	64.8	64.5	64.5	64.2	64.0
June 6	64.0	63.8	63.8	64.0	64.2	64.8	65.0	65.3	65.6	65.5	65.3	65.3
June 7	65.0	65.0	65.0	65.0	65.2	65.5	66.0	66.0	66.2	66.0	66.0	66.0
June 8	66.0	66.0	63.5	63.0	63.0	63.5	64.0	64.3	64.5	64.6	64.0	64.0
June 9	63.8	63.5	63.2	63.2	63.8	64.2	65.0	65.8	66.0	66.0	66.0	65.7
June 10	65.5	65.0	65.0	65.0	65.0	65.0	65.3	65.7	65.7	65.6	65.2	65.0
June 11	64.8	64.3	64.2	64.0	64.0	64.2	64.2	64.2	64.5	64.0	63.5	63.0
June 12	62.8	62.0	62.0	61.8	61.7	61.8	61.8	62.0	62.0	61.5	61.2	61.0
June 13	60.5	60.3	60.0	60.0	59.8	59.8	60.0	60.0	60.0	59.8	59.7	59.2
June 14	59.0	58.8	58.3	58.2	58.2	58.3	58.5	58.8	59.0	58.8	58.3	58.2
Sum	637.4	634.2	630.0	629.2	629.9	632.1	634.8	636.9	638.0	636.3	633.4	631.4
Corrected sum [a]	639.4	636.2	632.0	631.2	631.9	634.1	636.8	638.9	640.0	638.3	635.4	633.4
Average	63.94	63.62	63.20	63.12	63.19	63.41	63.68	63.89	64.00	63.83	63.54	63.34
June 15	58.2	56.0	56.0	56.2	56.3	56.5	56.8	57.3	57.6	57.6	57.6	57.6
June 16	57.3	57.2	57.0	57.3	57.8	58.8	59.5	60.0	60.5	60.8	60.8	60.8
June 17	60.5	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	59.8
June 18	59.5	59.3	59.0	59.0	59.4	60.0	60.8	61.3	61.8	61.8	61.7	61.3
June 19	61.2	61.0	61.0	60.8	61.0	61.2	61.8	62.2	62.5	62.6	62.5	62.4
June 20	62.2	62.0	62.0	61.5	61.2	61.2	61.2	61.3	61.4	61.3	61.2	61.2

[a] Correction at the rate of 0.2° daily on account of readings having been made from lower side of record mark.

Readings of the soil thermograph at even 2-hour intervals, beginning at 6 a. m., under corn on the Hagerstown clay loam 1 foot below the surface, at Lancaster, Pa., June 1 to September 20, arranged in 10-day periods—1903—Continued.

Date.	Hour of reading.											
	6.	8.	10.	Noon.	2.	4.	6	8.	10.	M.	2.	4.
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
June 21	61.0	61.0	61.0	61.0	61.2	61.4	61.8	62.0	62.3	62.2	62.0	61.7
June 22	61.0	61.0	61.0	60.5	60.8	61.5	62.2	62.5	62.6	62.5	62.2	62.0
June 23	61.4	61.0	60.5	60.2	60.0	60.0	60.0	60.0	60.0	59.8	59.6	59.4
June 24	59.2	59.0	59.0	59.0	59.0	59.2	59.8	60.3	60.5	60.5	60.3	60.2
Sum	601.5	597.5	596.5	595.5	596.7	599.8	603.9	606.9	609.2	609.1	607.9	606.4
Corrected sum [a]	603.5	599.5	598.5	597.5	598.7	601.8	605.9	608.9	611.2	611.1	609.9	608.4
Average	60.35	59.95	59.85	59.75	59.87	60.18	60.59	60.89	61.12	61.11	60.99	60.84
June 25	60.0	59.9	59.5	59.3	59.2	59.3	59.7	60.0	60.2	60.2	60.0	60.0
June 26	60.0	60.0	60.0	60.0	60.2	60.8	61.5	62.0	62.3	62.5	62.2	62.0
June 27	61.8	61.6	61.5	61.6	61.8	62.3	62.8	63.2	63.5	63.5	63.3	63.0
June 28	63.0	62.7	62.4	62.2	62.1	62.1	62.2	62.2	62.1	62.0	61.8	61.6
June 29	61.5	61.5	61.4	61.4	61.5	61.8	62.1	62.5	62.7	62.8	62.5	62.3
June 30	62.0	61.8	61.6	61.8	62.3	63.0	64.0	64.8	65.0	65.2	65.0	65.0
July 1	64.8	64.5	64.3	64.5	65.0	66.0	66.8	67.0	68.0	68.0	68.0	67.8
July 2	67.3	67.1	67.0	67.0	67.6	68.3	69.0	69.8	70.1	70.1	70.0	69.8
July 3	69.3	69.0	68.8	68.8	69.1	70.0	70.8	71.0	71.0	70.6	70.0	69.7
July 4	69.2	69.0	68.7	68.6	68.7	69.0	69.3	69.8	70.0	70.0	69.5	69.2
Sum	638.9	637.1	633.2	635.2	637.5	642.6	648.2	652.8	654.9	654.9	652.3	650.4
Corrected sum [a]	640.9	639.1	635.2	637.2	639.5	644.6	650.2	654.8	656.9	656.9	654.3	652.4
Average	64.09	63.91	63.52	63.72	63.95	64.46	65.02	65.48	65.69	65.69	65.43	65.24
July 5	69.0	68.5	68.3	68.2	68.5	69.0	69.2	69.3	69.4	69.2	69.0	68.8
July 6	68.6	68.5	68.2	68.0	68.6	69.3	70.0	70.5	70.6	70.5	70.0	69.7
July 7	69.0	68.2	68.0	68.0	68.2	68.8	69.8	70.3	70.5	70.3	70.0	69.7
July 8	69.3	68.8	68.3	68.5	68.8	69.8	70.8	71.4	71.7	71.6	71.3	71.0
July 9	70.5	70.0	70.0	70.0	70.3	71.0	72.0	72.8	73.0	73.0	72.8	72.3
July 10	72.0	71.3	71.1	71.0	71.6	72.3	73.1	73.4	73.4	73.0	72.8	72.3
July 11	72.0	71.6	71.3	71.4	72.0	72.7	72.8	72.8	72.5	72.2	72.0	71.5
July 12	71.0	70.8	70.5	70.8	71.0	71.3	71.4	71.3	71.2	71.1	70.8	70.5
July 13	70.2	69.5	69.5	69.0	69.0	69.0	69.2	69.2	69.0	69.0	68.5	68.2
July 14	68.0	67.5	67.2	67.2	67.5	68.0	68.8	69.0	69.0	68.7	68.2	67.8
Sum	699.6	694.7	692.4	692.2	695.5	701.2	707.1	710.0	710.3	708.6	705.4	701.8
Corrected sum [a]	701.6	696.7	694.4	694.2	697.5	703.2	709.1	712.0	712.3	710.6	707.4	703.8
Average	70.16	69.67	69.44	69.42	69.75	70.32	70.91	71.20	71.23	71.06	70.74	70.38
July 15	67.2	66.7	66.2	66.0	66.3	66.6	67.0	67.2	67.2	66.8	66.5	66.0
July 16	65.6	65.2	65.0	65.0	65.3	66.0	66.7	67.0	67.2	67.2	66.8	66.3
July 17	66.0	65.5	65.3	65.3	65.8	66.5	67.2	67.8	68.0	68.0	67.7	67.3
July 18	67.0	67.0	66.6	66.4	66.3	66.3	66.3	66.3	66.3	66,3	66.2	66.1
July 19	66.0	65.5	65.2	65.3	65.8	66.3	66.8	67.3	67.7	67.8	67.5	67.3
July 20	67.0	67.0	67.0	67.0	67.2	67.8	68.1	68.5	68.7	68.6	68.2	67.9
July 21	67.4	67.0	66 8	66.5	66.8	67.0	67.8	68.0	68.3	68.3	68.2	68.0
July 22	67.5	67.2	67.0	67.0	67.2	67.5	68.0	68.5	68.7	68.7	68.3	68.1
July 23	67.8	67.3	67.0	67.0	67.1	67.2	67.6	68.0	68.2	68.2	68.0	67.8
July 24	67.4	67.1	67.0	66.8	67.0	67.5	68.2	69.0	69.3	69.2	69.0	68.5
Sum	668.2	665.5	663.1	662.3	664.8	668.7	673.7	677.2	679.6	679.1	676.4	673.3
Corrected sum [a]	670.2	667.5	665.1	664.3	666.8	670.7	675.7	679.2	681.6	681.1	678.4	675.3
Average	67.02	66.75	66.51	66.43	66.68	67.07	67.57	67.92	68.16	68.11	67.84	67.53
July 25	67.8	67.0	66.8	66.8	67.0	67.8	68.5	69.0	69.5	69.8	69.5	69.3
July 26	69.1	69.0	69.0	68.8	68.9	69.2	69.6	70.0	70.0	70.0	69.7	69.4
July 27	69.0	68.8	68.2	68.0	68.2	68.8	69.0	69.6	69.6	69.3	68.8	68.3
July 28	67.8	67.0	67.0	66.5	66.5	66.8	67.3	67.8	68.0	68.0	6[illegible].7	67.6
July 29	67.3	67.0	67.0	67.0	67.2	67.8	68.5	69.0	69.2	69.2	69.2	69.0
July 30	68.8	68.6	68.3	68.5	69.0	69.3	70.0	70.2	70.3	70.2	70.0	69.8
July 31	69.7	69.3	69.0	69.0	68.8	68.8	68.3	68.2	68.0	67.6	67.2	67.0
August 1	66.3	66.0	65.3	65.3	65.5	66.0	66.3	66.8	66.9	66.7	66.3	66.0
August 2	65.5	65.0	64.8	64.8	65.0	65.3	65.7	66.0	66.3	66.3	66.2	66.0
August 3	65.8	66.0	66.2	66.2	66.3	66.8	67.0	67.2	67.3	67.2	67.0	67.0
Sum	673.7	673.7	671.6	670.9	672.4	676.6	681.2	683.8	685.1	684.3	681.6	679.4
Corrected sum [a]	675.7	675.7	673.6	672.9	674.4	678.6	683.2	685.8	687.1	686.3	683.6	681.4
Average	67.57	67.57	67.36	67.29	67.44	67.86	68.32	68.58	68.71	68.63	68.36	68.14
August 4	66.6	66.3	66.2	66.0	66.0	65.7	65.7	65.5	65.5	65.3	65.3	65.3
August 5	65.1	65.1	65.1	65.0	65.2	65.5	66.0	66.3	66.6	66.6	66.5	66.3
August 6	66.0	65.8	65.7	65.5	65.3	65.3	65.4	65.5	65.6	65.7	65.6	65.3
August 7	65.1	65.0	64.8	64.7	65.0	65.2	65.8	66.0	66.0	65.8	65.3	65.0
August 8	64.3	63.8	63.2	63.1	63.2	63.6	64.0	64.4	64.5	64.7	64.5	64.3

[a] Correction at the rate of 0.2° daily on account of readings having been made from lower side of record mark.

Readings of the soil thermograph at even 2-hour intervals, beginning at 6 a. m., under corn on the Hagerstown clay loam 1 foot below the surface, at Lancaster, Pa., June 1 to September 20, arranged in 10-day periods—1903—Continued.

Date.	Hour of reading.											
	6.	8.	10.	Noon	2.	4.	6.	8.	10.	M.	2.	4.
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
August 9	64.2	64.0	64.0	64.1	64.2	64.8	65.3	66.0	66.1	66.2	66.1	66.0
August 10	66.0	66.0	66.3	66.2	66.6	67.0	67.8	68.2	68.5	68.6	68.5	68.4
August 11	68.2	68.1	68.0	68.0	68.0	68.2	68.8	69.0	69.0	68.8	68.6	68.3
August 12	68.0	67.8	67.2	67.1	67.1	67.5	67.9	68.0	68.0	67.8	67.6	67.1
August 13	66.8	66.2	65.8	65.6	65.8	66.0	66.2	66.5	66.6	66.5	66.4	66.2
Sum	660.3	658.1	656.3	655.3	656.4	658.8	662.9	665.4	666.4	666.0	664.0	662.0
Corrected sum [a]	662.3	660.1	658.3	657.3	658.4	660.8	664.9	667.4	668.4	668.0	666.4	664.2
Average	66.23	66.01	65.83	65.73	65.84	66.08	66.49	66.74	66.84	66.80	66.64	66.42
August 14	66.2	66.0	65.8	65.5	65.5	65.5	65.7	65.8	65.8	65.6	65.2	65.0
August 15	64.8	64.5	64.2	64.2	64.4	64.9	65.4	65.9	66.0	66.1	66.0	65.8
August 16	65.5	65.2	65.1	65.0	65.0	65.1	65.2	65.3	65.3	65.3	65.2	65.1
August 17	65.0	64.8	64.3	64.3	64.6	65.0	65.7	66.1	66.3	66.3	66.1	66.0
August 18	65.6	65.2	65.0	65.0	65.2	65.8	(b)	(b)	(b)	(b)	(b)	(b)
August 19 to 23	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
Sum	327.1	325.7	324.4	324.0	324.7	326.3	262.0	263.1	263.4	263.3	262.5	261.9
Corrected sum [a]	328.1	326.7	325.4	325.0	325.7	327.3	262.8	263.9	264.2	264.1	263.3	262.9
Average	65.62	65.34	65.08	65.00	65.14	65.48	65.70	65.98	66.05	66.03	65.83	65.73
August 24	69.3	69.0	68.3	68.2	68.3	68.8	69.5	69.8	69.8	70.0	69.8	69.7
August 25	69.5	69.3	69.2	69.2	69.4	70.0	70.7	71.0	71.1	71.1	71.0	70.6
August 26	70.3	70.1	70.0	70.0	70.2	70.7	71.3	71.6	71.7	71.5	71.1	70.6
August 27	70.2	70.0	69.5	69.3	69.2	69.3	69.6	69.6	69.6	69.2	69.1	69.0
August 28	68.5	68.0	67.8	67.6	67.4	67.3	67.1	67.0	66.8	66.7	66.3	66.2
August 29	66.0	65.8	65.5	65.2	65.2	65.1	65.0	65.0	64.8	64.6	64.2	64.0
August 30	63.8	63.5	63.2	63.0	63.0	63.0	63.1	63.1	63.1	63.2	63.2	63.2
August 31	63.1	62.5	62.5	62.5	62.5	62.5	62.7	62.8	62.8	62.9	63.0	62.8
September 1	62.6	62.4	62.4	62.4	62.7	63.1	63.2	63.8	64.1	64.1	64.0	63.8
September 2	63.6	63.3	63.2	63.3	63.8	64.2	65.0	65.3	65.6	65.7	65.5	65.3
Sum	666.9	663.9	661.6	660.7	661.7	664.0	667.2	669.0	669.4	669.0	667.2	665.2
Corrected sum [a]	668.9	665.9	663.6	662.7	663.7	666.0	669.2	671.0	671.4	671.0	669.2	667.2
Average	66.89	66.59	66.36	66.27	66.37	66.60	66.92	67.10	67.14	67.10	66.92	66.72
September 3	65.1	65.0	65.0	65.0	65.3	66.0	66.7	67.0	67.1	67.0	66.8	66.5
September 4	66.1	65.8	65.6	65.7	66.0	66.8	67.3	67.8	67.9	67.8	67.3	67.1
September 5	67.0	66.6	66.2	66.3	66.8	67.3	68.0	68.1	68.1	68.0	67.8	67.2
September 6	66.8	66.2	66.0	65.8	65.9	66.1	66.3	66.3	66.2	65.8	65.3	64.8
September 7	64.1	63.5	62.8	62.3	62.2	62.6	63.1	63.5	63.6	63.5	63.3	63.2
September 8	63.1	63.0	62.7	62.2	62.0	62.0	62.0	62.0	61.8	61.8	61.5	61.3
September 9	61.2	61.1	61.0	61.0	61.1	61.2	61.3	61.6	61.8	61.9	62.0	62.0
September 10	62.0	62.0	62.0	62.2	62.7	63.2	63.9	64.4	64.8	65.0	65.0	64.8
September 11	64.7	64.5	64.2	64.0	63.7	63.8	64.2	64.7	64.8	64.9	64.7	64.4
September 12	64.1	63.8	63.7	63.6	63.8	64.2	65.0	65.3	65.6	65.7	65.4	65.3
Sum	644.2	640.5	639.2	638.1	639.5	643.2	647.8	650.7	651.8	651.4	649.1	646.6
Corrected sum [a]	646.2	642.5	641.2	640.1	641.5	645.2	649.8	652.7	653.8	653.4	651.1	648.6
Average	64.62	64.25	64.12	64.01	64.15	64.52	64.98	65.27	65.38	65.34	65.11	64.86
September 13	65.1	65.0	65.0	65.0	65.3	66.1	66.8	67.1	67.2	67.1	66.8	66.6
September 14	66.2	66.2	66.0	65.8	66.0	66.8	67.2	67.6	67.7	67.6	67.3	67.0
September 15	66.8	66.2	66.1	66.1	66.4	67.0	67.6	68.0	68.0	67.8	67.6	67.2
September 16	67.0	66.8	66.5	66.3	66.3	66.8	67.3	67.7	67.8	67.7	67.4	67.2
September 17	67.1	67.1	67.1	67.0	67.0	67.3	67.6	67.5	67.2	67.0	66.3	65.8
September 18	65.0	64.5	63.8	63.4	63.4	63.5	63.7	63.7	63.3	62.8	62.2	61.8
September 19	61.0	60.5	60.0	60.4	60.8	61.0	61.2	61.1	61.0	60.8	60.5	60.0
September 20	59.5	58.8	58.3	58.2	58.4	59.0	59.8	60.0	60.0	59.8	59.6	59.1
Sum	517.7	515.1	512.8	512.2	513.6	517.5	521.2	522.7	522.2	520.6	517.7	514.7
Corrected sum [a]	519.3	516.7	514.4	513.8	515.2	519.1	522.8	524.3	523.8	522.2	519.3	516.3
Average	64.9	64.59	64.30	64.23	64.40	64.90	65.35	65.54	65.48	65.28	64.91	64.54

[a] Correction at the rate of 0.2° daily on account of readings having been made from lower side of record mark.
[b] Record blank for August 19 to 23.

Readings of the soil thermograph at even 2-hour intervals, beginning at 6 a. m., under corn on the Hagerstown loam 1 foot below the surface, at Lancaster, Pa., June 1 to September 20, arranged in 10-day periods—1903.

Date.	Hour of reading.											
	6.	8.	10.	Noon	2.	4.	6.	8.	10.	M.	2.	4.
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
June 1	......	......	61.0	60.3	60.3	60.6	61.2	61.7	62.0	62.1	62.1	62.1
June 2	62.0	61.8	61.5	61.4	61.5	61.8	62.2	62.8	63.2	63.3	63.3	63.2
June 3	63.0	62.8	62.3	62.1	62.2	62.6	63.0	63.5	63.8	64.0	64.0	64.0
June 4	63.8	63.5	63.2	63.0	63.3	63.8	64.2	64.8	65.2	65.4	65.3	65.2
Sum	188.8	188.1	248.0	246.8	247.3	248.8	250.6	252.8	254.2	254.8	254.7	254.5
Corrected sum[a]	189.4	188.7	248.8	247.6	248.1	249.6	251.4	253.6	255.0	255.6	255.5	255.3
Average	63.13	62.90	62.20	61.90	62.03	62.40	62.85	63.40	63.75	63.90	63.89	63.83
June 5	65.0	64.8	64.6	64.2	64.1	64.0	64.0	64.0	64.0	64.0	64.0	64.0
June 6	63.8	63.5	63.3	63.0	63.1	63.3	63.6	63.8	63.9	64.0	64.0	64.0
June 7	64.0	63.8	63.8	63.6	63.6	63.7	63.8	64.0	64.1	......	......	......
June 8	65.0	65.0	65.0	65.0	65.0	65.1	65.4	65.7	65.9	66.0	66.0	65.8
June 9	65.6	65.2	65.1	65.1	65.2	65.8	66.3	66.9	67.2	67.3	67.2	67.2
June 10	67.0	66.8	66.7	66.7	66.7	66.8	67.0	67.2	67.3	67.2	67.1	67.0
June 11	66.8	66.6	66.3	66.2	66.2	66.2	66.2	66.2	66.2	66.0	65.8	65.5
June 12	65.0	64.8	64.6	64.3	64.1	64.1	64.1	64.1	64.0	63.9	63.8	63.4
June 13	63.0	62.8	62.4	62.2	62.1	62.2	62.2	62.2	62.3	62.1	62.0	61.9
June 14	61.6	61.3	61.1	61.0	61.0	61.0	61.1	61.2	61.3	61.3	61.1	61.0
Sum	646.8	644.6	642.9	641.3	641.1	642.2	643.9	645.3	646.2	581.8	581.0	579.8
Corrected sum[a]	648.8	646.6	644.9	643.3	643.1	644.2	645.9	647.3	648.2	583.6	582.8	581.6
Average	64.88	64.66	64.49	64.33	64.31	64.42	64.59	64.73	64.82	64.84	64.75	64.62
June 15	60.9	60.8	60.7	60.2	60.0	60.0	60.2	60.3	60.5	60.7	60.7	60.5
June 16	60.3	60.2	60.1	60.2	60.6	61.0	61.4	61.9	62.1	62.4	62.5	62.5
June 17	62.3	62.2	62.1	62.0	61.9	61.8	61.8	61.8	61.8	61.7	61.6	61.5
June 18	61.3	61.2	61.1	61.0	61.1	61.5	62.0	62.5	62.9	63.0	63.1	63.0
June 19	63.0	62.8	62.6	62.6	62.7	62.9	63.2	63.7	63.8	64.0	64.1	64.1
June 20	64.0	63.9	63.7	63.4	63.2	63.1	63.1	63.1	63.2	63.3	63.3	63.3
June 21	63.3	63.3	63.3	63.3	63.3	63.5	63.8	64.0	64.1	64.1	64.0	63.9
June 22	63.6	63.2	63.0	62.6	62.5	62.7	63.1	63.5	63.6	63.8	63.7	63.4
June 23	63.1	63.0	62.8	62.3	62.1	62.0	62.0	62.0	62.0	62.0	62.0	61.8
June 24	61.6	61.4	61.2	61.2	61.2	61.3	61.6	61.8	61.9	62.0	61.9	61.8
Sum	623.4	622.0	620.6	618.8	618.6	619.8	622.3	624.6	625.9	627.0	626.9	625.8
Corrected sum[a]	625.4	624.0	622.6	620.8	620.6	621.8	624.3	626.6	627.9	629.0	628.9	627.8
Average	62.54	62.40	62.26	62.08	62.06	62.18	62.43	62.66	62.79	62.90	62.89	62.78
June 25	61.6	61.4	61.2	61.1	61.0	61.0	61.2	61.3	61.5	61.7	61.8	61.8
June 26	61.6	61.5	61.5	61.4	61.7	62.0	62.2	62.7	62.9	63.0	63.0	63.0
June 27	62.9	62.8	62.8	62.8	63.0	63.2	63.8	64.0	64.2	64.3	64.3	64.2
June 28	64.1	64.0	64.0	63.9	64.0	64.0	64.0	64.0	64.0	64.0	63.9	63.8
June 29	63.7	63.5	63.4	63.2	63.1	63.2	63.4	63.7	63.8	63.9	63.9	63.8
June 30	63.7	63.5	63.2	63.2	63.4	63.9	64.3	64.9	65.2	65.5	65.5	65.5
July 1	65.4	65.2	65.1	65.2	65.7	66.0	66.7	67.0	67.3	67.6	67.7	67.7
July 2	67.6	67.4	67.2	67.3	67.7	68.0	68.6	69.0	69.2	69.4	69.5	69.4
July 3	69.1	69.0	68.8	68.9	69.2	69.8	70.2	70.5	70.6	70.5	70.3	70.1
July 4	70.0	69.7	69.4	69.3	69.4	69.7	69.9	70.1	70.2	70.3	70.2	70.0
Sum	649.7	648.0	646.6	646.3	648.2	650.8	654.3	657.2	658.9	660.2	660.1	659.3
Corrected sum[a]	651.7	650.0	648.6	648.3	650.2	652.8	656.3	659.2	660.9	662.2	662.1	661.3
Average	65.17	65.00	64.86	64.83	65.02	65.28	65.63	65.92	66.09	66.22	66.21	66.13
July 5	69.8	69.4	69.3	69.1	69.2	69.3	69.5	69.7	69.8	69.8	69.6	69.5
July 6	69.5	70.0	69.5	69.2	69.5	70.0	70.3	70.5	71.0	71.0	70.8	70.5
July 7	70.0	69.8	69.0	69.0	69.0	69.5	70.0	70.0	70.7	70.8	70.5	70.3
July 8	70.0	69.9	69.5	69.3	69.8	70.0	70.8	71.5	71.8	71.8	71.8	71.7
July 9	71.5	71.3	71.0	71.0	71.5	71.8	72.0	72.8	73.0	73.2	73.0	72.7
July 10	72.7	72.5	72.3	72.0	72.3	72.7	73.0	73.5	73.7	73.7	73.5	73.3
July 11	73.0	72.8	72.7	72.6	72.8	73.0	73.5	73.5	73.5	73.5	73.0	73.0
July 12	72.5	72.3	72.0	72.0	72.0	72.5	72.5	72.5	72.5	72.3	72.0	71.8
July 13	71.5	71.0	71.0	70.6	70.6	70.5	70.5	70.5	70.5	70.5	70.0	70.0
July 14	69.7	69.6	69.0	69.0	69.0	69.5	69.8	70.0	70.0	70.0	69.8	69.4
Sum	710.2	708.6	705.3	703.8	705.2	708.8	711.9	714.5	716.5	716.6	714.0	712.2
Corrected sum[a]	712.2	710.6	707.3	705.8	707.2	710.8	713.9	716.5	718.5	718.6	716.0	714.2
Average	71.22	71.06	70.73	70.58	70.72	71.08	71.39	71.65	71.85	71.86	71.60	71.42
July 15	69.0	68.8	68.2	68.0	68.0	68.0	68.0	68.0	68.0	67.9	67.7	67.5
July 16	67.0	66.8	66.5	66.2	66.5	66.7	67.0	67.5	67.8	67.8	67.8	67.5
July 17	67.2	67.0	66.8	66.8	66.9	67.2	67.8	68.0	68.5	68.7	68.6	68.5
July 18	68.2	68.0	68.0	68.0	67.9	67.8	67.8	67.8	67.8	67.8	67.8	67.6
July 19	67.4	67.2	67.1	67.1	67.2	67.7	67.9	68.2	68.7	68.8	68.8	68.7

[a] Corrections of 0.2° daily on account of readings having been made from lower side of record mark.

Readings of the soil thermograph at even 2-hour intervals, beginning at 6 a. m., under corn on the Hagerstown loam 1 foot below the surface, at Lancaster, Pa., June 1 to September 20, arranged in 10-day periods—1903—Continued.

Date.	Hour of reading.											
	6.	8.	10.	Noon	2.	4.	6.	8.	10.	M.	2.	4.
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
July 20	68.7	68.6	68.5	68.0	68.1	68.3	68.9	69.2	69.5	69.7	69.5	69.3
July 21	69.0	68.8	68.3	68.1	68.1	68.2	68.8	69.0	69.2	69.5	69.3	69.2
July 22	69.1	69.0	68.8	68.8	68.8	68.9	69.1	69.5	69.8	69.9	69.8	69.6
July 23	69.3	69.1	68.9	68.8	68.8	68.9	69.0	69.3	69.6	69.4	69.2	69.0
July 24	68.8	68.6	68.4	68.4	68.7	68.9	69.3	69.9	70.0	70.1	70.0	69.6
Sum	683.7	681.9	679.5	678.2	679.0	680.6	683.6	686.4	688.9	689.6	688.5	686.5
Corrected sum [a]	685.7	683.9	681.5	680.2	681.0	682.6	685.6	688.4	690.9	691.6	690.5	688.5
Average	68.57	68.39	68.15	68.02	68.10	68.26	68.56	68.84	69.09	69.16	69.05	68.85
July 25	69.1	68.9	68.4	68.3	68.4	69.0	69.5	70.0	70.5	70.8	70.9	70.7
July 26	70.4	70.1	70.0	70.0	70.1	70.3	70.5	70.8	71.0	71.0	70.9	70.8
July 27	70.6	70.3	70.0	69.7	69.7	69.8	70.0	70.4	70.7	70.7	70.4	70.2
July 28	69.8	69.1	68.7	68.2	68.1	68.3	68.9	69.5	69.8	70.0	70.0	69.9
July 29	69.7	69.4	69.2	69.1	69.2	69.5	70.0	70.6	70.9	71.0	71.0	70.8
July 30	70.7	70.5	70.3	70.2	70.4	70.8	71.3	71.8	72.0	72.2	72.1	72.0
July 31	71.8	71.6	71.2	71.1	71.0	70.8	70.7	70.5	70.3	70.0	69.8	69.5
August 1	69.0	68.8	68.3	68.1	68.2	68.5	69.0	69.2	69.6	69.7	69.6	69.2
August 2	69.0	68.8	68.3	68.2	68.3	68.6	68.9	69.2	69.4	69.7	69.7	69.6
August 3	69.2	69.0	68.3	68.0	68.1	68.2	68.4	68.7	68.8	68.8	68.7	68.5
Sum	699.3	696.5	692.7	690.9	691.5	693.8	697.2	700.7	703.0	703.9	703.1	701.2
Corrected sum [a]	701.3	698.5	694.7	692.9	693.5	695.8	699.2	702.7	705.0	705.9	705.1	703.2
Average	70.13	69.85	69.47	69.29	69.35	69.58	69.92	70.27	70.50	70.59	70.51	70.32
August 4	68.3	68.1	68.0	67.8	67.5	67.3	67.2	67.0	66.9	66.9	66.7	66.6
August 5	66.5	66.3	66.2	66.2	66.1	66.4	66.8	67.0	67.2	67.3	67.3	67.3
August 6	67.1	67.0	66.8	66.6	66.5	66.4	66.4	66.4	66.5	66.6	66.6	66.5
August 7	66.2	66.1	66.0	66.0	66.1	66.2	66.7	66.8	66.9	66.8	66.5	66.1
August 8	65.7	65.2	65.0	64.9	64.9	65.1	65.4	65.8	65.9	66.0	65.9	65.8
August 9	65.7	65.5	65.4	64.3	65.4	65.8	66.0	66.5	66.9	67.1	67.1	67.0
August 10	67.0	67.2	67.2	67.3	67.4	67.7	68.2	68.8	69.1	69.2	69.3	69.3
August 11	69.2	69.1	69.0	69.0	68.9	68.9	69.0	69.3	69.6	69.8	69.8	69.6
August 12	69.0	68.7	68.3	68.0	68.1	68.2	68.6	68.8	68.9	68.9	68.7	68.4
August 13	68.0	67.8	67.2	67.0	67.0	67.1	67.3	67.5	67.7	67.8	67.7	67.5
Sum	672.7	670.9	669.1	668.1	667.9	669.1	671.6	673.9	675.6	676.4	675.6	674.1
Corrected sum [a]	674.7	672.9	671.1	670.1	669.9	671.1	673.6	675.9	677.6	678.4	677.6	676.1
Average	67.47	67.29	67.11	67.01	66.99	67.11	67.36	67.59	67.76	67.84	67.76	67.61
August 14	67.3	67.1	67.0	67.0	67.0	67.0	67.0	67.1	67.1	67.0	66.9	66.7
August 15	66.3	66.1	66.0	65.9	66.0	66.2	66.8	67.0	67.3	67.4	67.4	67.2
August 16	67.0	66.9	66.7	66.5	66.5	66.5	66.6	66.7	66.7	66.7	66.4	66.3
August 17	66.0	65.3	64.8	64.5	64.6	64.8	65.2	65.8	66.0	66.1	66.1	66.0
August 18	65.8	65.6	65.3	65.1	65.2	65.4	65.8	66.1	66.3	66.4	66.3	66.2
August 19	66.0	65.9	65.8	65.8	65.9	66.0	66.3	66.6	66.8	66.9	66.9	66.8
August 20	66.8	66.7	66.5	66.5	66.6	66.8	67.0	67.1	67.3	67.3	67.1	66.9
August 21	66.8	66.2	66.0	65.8	65.8	66.0	66.3	66.7	66.9	66.9	66.7	66.3
August 22	66.0	65.7	65.3	65.2	65.3	65.8	66.0	66.7	66.8	67.0	67.0	67.0
August 23	67.0	66.8	66.8	66.7	66.8	67.1	67.6	68.0	68.1	68.3	68.3	68.2
Sum	665.0	662.3	660.2	659.0	659.7	661.6	664.6	667.8	669.3	670.0	669.1	667.6
Corrected sum [a]	667.0	664.3	662.2	661.0	661.7	663.6	666.6	669.8	671.3	672.0	671.1	669.6
Average	66.70	66.43	66.22	66.10	66.17	66.36	66.66	66.98	67.13	67.20	67.11	66.96
August 24	68.1	68.0	68.0	67.8	67.9	68.0	68.4	68.8	69.0	69.1	69.1	69.0
August 25	68.9	68.8	68.8	68.7	68.8	69.1	69.5	69.9	70.1	70.2	70.2	70.0
August 26	69.9	69.8	69.5	69.4	69.4	69.6	70.0	70.2	70.3	70.4	70.3	70.0
August 27	69.8	69.4	69.1	69.0	68.9	69.0	69.0	69.1	69.1	69.1	69.0	68.9
August 28	68.4	68.1	68.0	67.8	67.6	67.4	67.3	67.2	67.1	67.0	66.9	66.8
August 29	66.4	66.2	66.1	66.0	65.8	65.8	65.6	65.4	65.2	65.0	64.9	64.6
August 30	64.2	64.0	63.9	63.7	63.4	63.3	63.2	63.2	63.1	63.0	63.0	63.0
August 31	62.9	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
September 1 to 6	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
Sum	538.6	474.3	473.4	472.4	471.8	472.2	473.0	473.8	473.9	473.8	473.2	472.3
Corrected sum [a]	540.2	475.7	474.8	473.8	473.2	473.6	474.4	475.2	475.3	475.2	474.6	473.7
Average	67.53	67.96	67.83	67.69	67.60	67.66	67.77	67.89	67.90	67.89	67.80	67.67
September 7	......	63.0	62.9	62.9	62.7	62.7	62.8	62.9	62.9	62.9	62.8	62.7
September 8	62.5	62.2	62.1	62.0	61.9	61.9	61.8	61.7	61.7	61.7	61.6	61.5
September 9	61.4	61.3	61.2	61.2	62.0	62.5	62.8	63.0	63.1	63.2	63.3	63.3
September 10	63.4	63.6	63.7	63.8	64.0	64.2	64.8	65.2	65.6	65.8	66.0	66.1

[a] Corrections of 0.2° daily on account of readings having been made from lower side of record mark.
[b] Record blank August 31 to September 6.

Readings of the soil thermograph at even 2-hour intervals, beginning at 6 a. m., under corn on the Hagerstown loam 1 foot below the surface, at Lancaster, Pa., June 1 to September 20, arranged in 10-day periods—1903—Continued.

Date.	Hour of reading.											
	6.	8.	10.	Noon	2.	4.	6.	8.	10.	M.	2.	4.
	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*
September 11	66.0	65.9	65.8	65.7	65.8	66.0	66.4	66.9	67.0	67.1	67.1	67.1
September 12	67.0	66.9	66.6	66.3	66.3	66.7	67.0	67.3	67.6	67.8	67.7	67.6
Sum	319.3	382.9	382.3	381.9	382.7	384.0	385.6	387.0	387.9	388.5	388.5	388.3
Corrected sum [a]	320.3	384.1	383.5	383.1	383.9	385.2	386.8	388.2	389.1	389.7	389.7	389.5
Average	64.04	64.02	63.92	63.85	63.98	64.20	64.47	64.70	64.85	64.95	64.95	64.92
September 13	67.4	67.2	67.1	67.0	67.2	67.7	68.0	68.2	68.5	68.7	68.7	68.4
September 14	68.3	68.2	68.0	67.9	67.8	68.0	68.1	68.6	68.8	68.9	68.8	68.7
September 15	68.4	68.2	68.1	68.0	68.0	68.2	68.8	69.0	69.1	69.2	69.1	69.0
September 16	68.8	68.4	68.2	68.0	68.0	68.2	68.7	69.0	69.1	69.1	69.1	69.1
September 17	69.0	69.0	69.0	69.0	69.0	69.1	69.1	69.1	69.0	68.8	68.3	68.0
September 18	67.5	67.0	66.5	65.9	65.8	65.8	65.8	65.8	65.6	65.2	64.9	64.3
September 19	63.9	63.4	63.0	62.8	62.8	62.9	63.0	63.1	63.2	63.1	62.9	62.4
September 20	62.0	61.8	61.3	61.1	61.0	61.3	61.8	62.0	62.1	62.1	62.0	61.8
Sum	535.3	533.2	531.2	529.7	529.6	531.2	533.3	534.8	535.4	535.1	533.8	531.7
Corrected sum [a]	536.9	534.8	532.8	531.3	531.2	532.4	534.9	536.4	537.0	536.7	536.4	533.3
Average	67.11	66.85	66.60	66.41	66.40	66.55	66.86	67.05	67.13	67.09	67.05	66.67

[a] Corrections of 0.2° daily on account of readings having been made from lower side of record mark.

Readings of the soil thermograph at even 2-hour intervals beginning at 6 a. m., under corn on the Janesville loam, 1 foot below the surface, at Janesville, Wis., June 8 to September 20, arranged in 10-day periods—1903.

Date.	Hour of reading.											
	6.	8.	10.	Noon.	2.	4.	6.	8.	10.	M.	2.	4.
	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*
June 8 [a]	......	......	62.0	61.0	60.8	61.3	62.0	62.8	63.0	63.0	62.8	62.5
June 9 [a]	61.8	61.3	61.3	61.2	61.3	61.6	61.8	62.3	62.4	62.2	62.0	61.5
June 10 [a]	61.0	60.3	59.8	59.5	59.0	59.0	58.8	58.8	58.0	58.5	57.8	57.3
June 11 [a]	56.8	56.0	55.7	55.3	55.1	55.1	55.2	55.3	55.3	55.3	55.2	54.8
June 12 [a]	54.3	53.8	53.4	53.4	53.8	54.5	55.3	56.0	56.3	56.6	56.3	56.0
June 13 [a]	55.6	55.2	54.8	55.0	55.3	56.0	56.8	57.5	57.9	58.0	58.0	58.0
June 14 [a]	57.8	57.6	57.5	57.7	58.0	59.0	60.0	60.8	61.3	61.6	61.6	61.5
Sum	347.3	344.2	404.5	403.1	403.3	406.5	409.9	413.5	405.0	415.2	413.7	411.6
Average	57.88	57.37	57.79	57.59	57.61	58.07	58.56	59.07	57.86	59.29	59.1	58.8
June 15 [b]	61.3	61.0	62.8	62.0	62.2	62.8	63.7	64.3	64.8	64.8	64.8	64.5
June 16 [b]	64.0	63.8	63.3	63.1	63.0	63.0	63.2	63.7	63.9	63.7	63.3	62.8
June 17 [b]	62.3	61.8	61.2	61.2	61.7	62.3	63.0	63.7	64.0	64.0	63.8	63.5
June 18 [b]	62.8	62.5	62.0	62.0	62.2	62.8	63.5	64.0	64.5	64.8	64.7	64.7
June 19 [b]	64.2	64.0	63.7	63.5	63.6	63.6	63.6	63.5	63.0	62.8	62.3	62.0
June 20 [b]	61.5	61.2	61.0	61.0	61.5	62.0	62.7	63.0	63.3	63.3	63.0	62.7
June 21 [b]	62.0	61.8	61.7	61.8	62.0	62.3	62.8	63.0	63.0	62.8	62.7	62.5
June 22	62.3	60.5	60.2	60.0	60.2	60.4	60.8	61.0	61.0	60.8	60.5	60.0
June 23	59.3	59.0	58.8	58.8	59.0	59.7	60.3	60.8	61.0	60.8	60.7	60.2
June 24	60.0	59.5	59.2	59.5	60.0	60.7	61.3	61.8	62.0	61.8	61.5	61.0
Sum	619.7	615.1	613.9	612.9	615.4	619.6	624.9	628.8	630.5	629.6	627.3	623.9
Average	61.97	61.51	61.39	61.29	61.54	61.96	62.49	62.88	63.05	62.96	62.73	62.39
June 25	60.8	60.2	60.2	60.3	60.8	61.5	62.3	62.8	63.0	63.0	62.7	62.3
June 26	62.0	62.5	61.2	61.5	62.0	62.7	63.5	64.0	64.2	64.0	63.8	63.5
June 27	62.8	62.5	62.4	62.8	63.3	64.0	64.8	65.0	65.3	65.2	65.0	64.5
June 28	64.0	63.8	63.5	63.8	64.0	64.5	65.0	65.7	65.9	65.9	65.7	65.4
June 29	65.0	62.0	62.0	61.0	61.0	61.2	61.7	62.2	62.5	62.8	62.5	62.3
June 30	62.0	62.0	61.8	61.7	61.7	61.9	62.0	62.2	62.2	62.0	62.0	62.0
July 1	62.0	61.8	61.8	62.0	62.2	62.8	63.3	64.0	64.3	64.6	64.4	64.0
July 2	63.8	63.4	63.0	63.2	63.5	64.0	64.8	65.0	65.2	65.3	65.2	65.0
July 3	64.8	64.3	64.2	64.2	64.7	65.0	65.4	65.8	66.0	65.8	65.5	65.2
July 4	65.0	64.8	64.5	64.5	64.7	65.0	65.2	65.2	65.0	64.8	64.7	64.0
Sum	632.2	627.3	624.6	625.0	627.9	632.6	638.0	641.9	643.6	643.4	641.5	638.2
Average	63.22	62.73	62.46	62.50	62.79	63.26	63.80	64.19	64.36	64.34	64.15	63.82

[a] An error of 15° seems to have been made in setting the pen, so that 15° had to be added to each reading for this week, and the corrected figures are used in the table.

[b] On this sheet there appears to have been made an error of twice 15° in setting the pen, hence 30° was added, and the corrected figures are used instead of the originals.

Readings of the soil thermograph at even 2-hour intervals, beginning at 6 a. m., under corn on the Janesville loam 1 foot below the surface, at Janesville, Wis., June 8 to September 20, arranged in 10-day periods—1903—Continued.

Date.	Hour of reading.											
	6.	8.	10.	Noon	2.	4.	6.	8.	10.	M.	2.	4.
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
July 5	63.5	63.0	62.8	62.8	63.0	63.7	64.0	64.7	65.0	65.0	64.8	64.2
July 6	64.0	63.6	63.5	63.0	62.8	63.3	63.5	64.0	64.0	64.0	63.8	63.3
July 7	63.0	62.3	62.0	62.0	62.3	63.0	63.3	63.8	64.0	64.0	63.8	63.7
July 8	63.2	63.0	62.7	62.8	63.0	63.8	64.3	65.0	65.2	65.3	65.2	65.0
July 9	64.8	64.5	64.0	64.0	64.0	64.3	64.8	65.0	65.0	64.8	64.3	64.2
July 10	64.0	63.5	63.3	63.3	63.8	64.0	64.5	64.8	64.8	64.5	64.2	64.0
July 11	63.8	63.5	63.5	63.5	63.8	64.2	64.8	65.1	65.2	65.0	65.0	64.7
July 12	64.0	63.8	63.5	63.5	63.7	64.0	64.0	64.2	64.0	63.8	63.0	62.8
July 13	62.0	65.0	65.0	65.0	65.0	65.2	65.3	65.7	65.8	65.8	65.3	65.0
July 14	64.7	64.0	63.8	63.5	63.7	64.0	64.5	65.0	65.2	65.2	65.0	64.8
Sum	637.0	636.2	634.1	633.4	635.1	639.5	643.0	647.3	648.2	647.4	644.4	641.7
Average	63.70	63.62	63.41	63.34	63.51	63.95	64.30	64.73	64.82	64.74	64.44	64.17
July 15	64.0	63.8	63.0	63.0	63.0	63.2	63.8	64.0	64.5	64.6	64.3	64.2
July 16	64.0	63.5	63.2	63.2	63.3	63.7	64.3	64.8	65.2	65.3	65.2	65.0
July 17	64.7	64.2	64.0	63.8	63.5	63.3	63.3	63.3	63.3	63.1	63.0	62.8
July 18	62.7	62.5	62.5	62.6	62.8	63.0	63.5	63.8	64.0	64.0	64.0	63.8
July 19	63.5	63.0	63.0	63.0	63.0	63.2	63.5	63.8	63.8	63.8	63.6	63.3
July 20	63.0	62.8	......	62.0	61.8	62.0	62.2	62.5	62.7	62.8	62.8	62.5
July 21	62.2	62.0	61.7	61.7	61.8	62.2	62.5	62.8	63.0	63.0	62.8	62.3
July 22	62.0	61.7	61.5	61.5	61.7	62.0	62.5	63.0	63.3	63.2	63.0	62.8
July 23	62.2	62.0	61.5	61.5	61.8	62.0	62.2	62.7	63.0	63.5	63.2	63.0
July 24	62.8	62.0	62.0	62.0	62.2	62.8	63.3	63.8	64.0	64.0	64.0	63.8
Sum	631.1	627.5	532.4	624.3	624.9	627.4	631.1	634.5	636.8	637.3	635.9	633.5
Average	63.11	62.75	62.49	62.43	62.49	62.74	63.11	63.45	63.68	63.73	63.59	63.35
July 25	63.5	63.0	63.0	63.0	63.5	64.0	64.2	64.8	64.8	65.0	65.0	65.0
July 26	65.0	65.0	65.0	64.8	64.8	64.8	65.0	65.0	65.0	64.5	64.3	64.0
July 27	63.6	63.5	67.0	67.0	67.0	67.2	67.5	67.8	68.0	68.0	67.8	67.5
July 28	67.5	67.2	67.0	67.2	67.5	68.0	68.5	68.8	69.0	69.0	69.0	68.8
July 29	68.7	68.5	68.3	68.2	68.2	68.5	68.7	68.8	69.0	68.8	68.7	68.3
July 30	68.0	67.5	67.2	67.2	67.0	67.0	67.2	67.3	67.2	67.0	66.5	66.0
July 31	65.3	65.0	64.5	64.5	64.7	65.0	65.2	65.3	65.3	65.2	65.0	64.7
August 1	64.3	64.0	64.0	64.0	64.0	64.2	64.3	64.5	64.7	65.0	64.5	64.2
August 2	64.0	64.0	64.0	64.0	64.5	65.0	65.7	66.0	66.5	66.7	66.6	65.5
August 3	66.5	68.0	68.0	67.8	67.8	68.0	68.2	68.3	68.3	68.2	68.0	67.8
Sum	656.4	655.7	658.0	657.7	659.0	661.7	664.5	666.6	667.8	667.4	665.4	661.8
Average	65.64	65.57	65.80	65.77	65.90	66.17	66.45	66.66	66.78	66.74	66.54	66.18
August 4	67.8	67.3	67.3	67.2	67.5	67.8	68.0	68.3	68.5	68.5	68.3	68.0
August 5	68.0	67.8	67.5	67.2	67.0	67.0	67.2	67.5	67.7	67.7	67.7	67.7
August 6	67.2	67.0	67.0	67.0	67.0	67.2	67.3	67.5	67.5	67.0	66.8	66.3
August 7	65.8	65.0	64.8	64.8	65.0	65.2	65.5	65.7	65.7	65.7	65.5	65.2
August 8	65.0	64.8	64.8	65.0	65.0	65.2	65.8	66.0	66.0	66.0	65.7	65.3
August 9	65.0	64.8	64.8	64.8	65.0	65.3	65.8	66.0	66.0	66.0	65.8	65.3
August 10	65.0	64.8	60.5	59.0	59.0	59.0	60.0	60.2	60.3	60.5	60.0	59.8
August 11	59.3	59.0	58.7	58.3	58.3	58.5	58.8	59.0	59.0	59.0	58.7	58.7
August 12	58.2	57.8	57.5	57.5	57.6	57.8	58.0	58.2	58.2	58.3	58.3	58.0
August 13	57.8	57.6	57.5	57.5	57.7	58.0	58.2	58.3	58.5	58.7	58.5	58.3
Sum	639.1	635.9	630.4	628.3	629.1	631.0	634.6	636.7	637.4	637.4	635.3	632.6
Average	63.91	63.59	63.04	62.83	62.91	63.10	63.46	63.67	63.74	63.74	63.53	63.26
August 14	58.1	58.0	58.0	58.0	58.1	58.2	58.5	58.9	59.0	59.0	59.0	58.8
August 15	58.5	58.2	58.0	58.0	58.0	58.2	58.3	58.5	58.7	59.0	59.0	59.0
August 16	58.7	58.3	58.2	58.2	58.3	58.8	59.0	59.3	59.6	59.8	59.7	59.3
August 17	59.0	58.8	70.5	70.5	70.0	70.3	70.5	70.8	71.0	71.1	71.2	71.0
August 18	70.8	70.5	70.2	70.3	70.3	70.5	71.0	71.5	71.8	72.0	72.0	72.0
August 19	72.0	71.8	71.6	71.5	71.5	71.8	72.0	72.3	72.3	72.2	72.0	71.8
August 20	71.3	71.0	70.7	70.5	70.7	70.9	71.0	71.6	71.7	71.8	71.5	71.3
August 21	71.2	71.0	70.7	70.5	70.7	71.0	71.2	71.3	71.5	71.5	71.5	71.5
August 22	71.3	71.2	71.2	71.3	71.3	72.0	72.2	72.2	72.5	72.5	72.7	72.7
August 23	72.7	72.5	72.5	72.5	72.8	73.0	73.2	73.5	74.0	74.0	74.0	73.8
Sum	663.6	661.3	671.6	671.3	671.7	674.7	676.9	679.9	682.1	682.9	682.6	681.2
Average	66.36	66.13	67.16	67.13	67.17	67.47	67.69	67.99	68.21	68.29	68.26	68.12
August 24	73.8	73.7	70.5	70.5	70.2	70.3	70.5	70.7	70.9	71.0	71.0	71.0
August 25	70.8	70.5	70.3	70.3	70.3	70.3	70.6	70.8	70.9	70.7	70.3	70.2
August 26	70.0	69.8	69.3	69.0	69.0	69.0	69.0	68.8	68.3	68.0	67.8	67.3
August 27	67.3	67.0	67.0	67.0	67.0	67.2	67.2	67.2	67.2	67.2	67.2	67.0
August 28	66.8	66.8	66.5	66.5	66.5	66.7	66.9	67.0	67.0	67.0	67.0	67.0
August 29	66.8	66.8	66.5	66.5	65.5	66.5	66.2	66.2	66.0	66.0	65.7	65.0
August 30	65.0	64.8	64.8	64.5	64.5	64.5	64.5	64.5	64.9	64.5	64.3	64.2

Readings of the soil thermograph at even 2-hour intervals beginning at 6 a. m., under corn on the Janesville loam, 1 foot below the surface, at Janesville, Wis., June 8 to September 20, arranged in 10-day periods—1903—Continued.

Date.	Hour of reading.											
	6.	8.	10.	Noon.	2.	4.	6.	8.	10.	M.	2.	4.
	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*
August 31	64.0	64.0	63.4	62.8	62.5	62.5	62.8	63.0	63.0	63.2	62.8	62.5
September 1	62.2	62.0	61.8	61.6	61.8	62.0	62.5	62.8	63.0	63.0	63.0	63.0
September 2	62.8	62.7	62.5	62.5	62.7	63.0	63.2	63.5	63.8	63.8	63.9	63.9
Sum	669.5	668.1	662.6	661.2	661.0	662.0	663.4	664.5	664.7	664.4	663.0	661.1
Average	66.95	66.81	66.26	66.12	66.10	66.20	66.34	66.45	66.47	66.44	66.30	66.11
September 3	63.8	63.7	63.6	63.5	63.6	63.8	64.0	64.5	64.5	64.5	64.6	64.6
September 4	64.3	64.0	64.0	63.8	64.0	64.0	64.0	64.0	64.0	63.6	63.5	63.2
September 5	63.0	62.7	62.5	62.5	62.5	62.7	62.9	63.0	63.0	62.8	62.7	62.0
September 6	61.8	61.3	61.0	61.0	61.0	61.0	61.0	61.0	61.0	61.0	61.0	60.8
September 7	60.7	60.6	61.0	64.0	63.8	64.0	64.3	64.5	65.0	65.2	65.5	65.5
September 8	65.7	65.8	65.7	66.0	66.0	66.3	66.8	67.0	67.5	67.5	67.5	67.5
September 9	67.4	67.4	67.4	67.3	67.3	67.2	67.4	67.6	67.5	67.0	67.0	66.8
September 10	66.0	66.0	65.8	65.7	65.7	65.8	66.0	66.0	66.0	66.0	65.8	65.5
September 11	65.2	65.0	64.8	64.6	64.7	65.0	65.0	65.2	65.5	65.7	65.7	65.7
September 12	65.8	65.9	66.0	66.0	66.5	66.7	66.8	67.0	67.2	67.6	67.6	67.6
Sum	643.7	642.4	641.8	644.4	645.3	646.5	648.2	649.8	651.2	651.1	650.9	649.2
Average	64.37	64.24	64.18	64.44	64.53	64.65	64.82	64.98	65.12	65.11	65.09	64.92
September 13	67.5	67.2	67.0	67.0	67.0	67.0	67.2	67.5	67.6	67.7	67.6	67.6
September 14	67.8	67.8	67.8	67.6	67.6	67.7	68.0	68.2	68.0	68.0	67.8	67.6
September 15	67.6	67.5	67.5	67.5	67.5	67.7	67.8	67.9	67.8	67.7	67.5	67.0
September 16	67.0	66.2	65.7	65.2	65.0	64.7	64.4	64.0	63.8	63.2	63.0	62.5
September 17	62.0	61.8	61.5	61.0	61.0	61.0	61.0	61.0	60.8	60.5	60.0	59.7
September 18	59.0	58.8	58.5	58.2	58.5	59.0	59.0	59.0	59.0	59.0	58.8	58.7
September 19	58.5	58.2	58.0	58.4	59.0	59.2	59.6	60.0	60.2	60.4	60.3	60.2
September 20	60.2	60.0	60.0	60.2	60.6	60.8	61.0	61.5	61.6	61.6	61.6	61.6
Sum	509.6	507.5	506.0	505.1	506.2	507.1	508.0	509.1	508.8	508.1	506.6	504.9
Average	63.70	63.44	63.25	63.14	63.28	63.39	63.50	63.64	63.60	63.51	63.32	63.11

Readings of the soil thermograph at even 2-hour intervals beginning at 6 a. m., under corn on the Miami loam, 1 foot below the surface, at Janesville, Wis., June 8 to September 20, arranged in 10-day periods—1903.

Date.	Hour of reading.											
	6.	8.	10.	Noon.	2.	4.	6.	8.	10.	M.	2.	4.
	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*
June 8 [a]	......	......	......	60.5	60.0	60.2	60.7	61.0	61.4	61.4	61.2	60.8
June 9 [a]	60.5	60.0	59.5	59.3	59.0	59.2	59.5	59.8	59.8	59.7	59.2	59.0
June 10 [a]	58.5	58.0	57.8	57.4	57.3	57.3	57.4	57.0	57.0	56.8	56.0	56.5
June 11 [a]	55.0	54.7	54.2	54.0	54.0	54.0	54.0	54.2	54.2	54.2	54.0	53.7
June 12 [a]	53.0	52.5	52.2	52.2	52.6	53.0	54.0	54.6	54.8	55.0	55.0	54.5
June 13 [a]	54.0	53.7	52.5	53.5	53.8	54.3	55.0	55.5	56.0	56.0	56.0	56.0
June 14 [a]	55.8	55.6	55.6	55.7	56.0	56.8	57.6	58.5	59.0	59.2	59.2	59.0
Sum	336.8	334.5	331.8	392.6	392.7	394.8	398.2	400.6	402.2	402.3	400.6	399.5
Average	56.13	55.75	55.3	56.09	56.09	56.40	56.89	57.22	57.46	57.47	57.23	57.07
June 15 [b]	58.8	58.5	62.0	59.8	59.0	59.6	60.0	61.0	61.5	61.2	61.1	60.8
June 16 [b]	60.5	60.0	60.0	59.8	59.8	59.7	60.0	60.2	60.5	60.5	60.0	59.8
June 17 [b]	59.0	58.5	58.0	58.0	58.0	58.6	59.0	59.8	60.0	60.0	60.0	59.7
June 18 [b]	59.0	58.8	58.2	58.0	58.2	58.7	59.5	60.0	60.5	60.6	60.6	60.5
June 19 [b]	60.0	59.8	59.7	59.5	59.7	60.0	60.0	60.0	59.8	59.6	59.2	58.8
June 20 [b]	58.2	57.8	57.7	57.6	57.8	58.5	59.0	59.8	60.0	60.0	59.8	59.5
June 21 [b]	59.0	58.6	58.5	58.2	58.5	59.0	59.5	60.0	60.0	60.0	59.8	59.7
June 22	59.2	59.0	61.0	61.0	61.0	61.5	61.8	62.0	62.0	61.8	61.5	61.0
June 23	60.3	60.0	59.5	59.5	59.8	60.0	60.7	61.2	61.5	61.5	61.2	60.7
June 24	60.5	60.0	60.0	60.0	60.5	61.0	61.9	62.5	62.6	62.5	62.5	62.0
Sum	594.5	591.0	594.6	591.4	592.3	596.6	601.4	606.5	608.4	607.7	605.7	602.5
Average	59.45	59.1	59.46	59.14	59.23	59.66	60.1[illegible]	60.65	60.84	60.77	60.55	60.25

[a] An error of 15° appears to have been made in setting the pen, so that 15° had to be added to each reading for this week, and the corrected figures appear here instead of the originals.

[b] On this sheet there appears to have been made an error of twice 15° in setting the pen, hence 30° had to be added, and the corrected figures appear here instead of the originals.

Readings of the soil thermograph at even 2-hour intervals beginning at 6 a. m., under corn on the Miami loam, 1 foot below the surface, at Janesville, Wis., June 8 to September 20, arranged in 10-day periods—1903—Continued.

Date.	Hour of reading.											
	6.	8.	10.	Noon.	2.	4.	6.	8.	10.	M.	2.	4.
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
June 25	61.5	61.0	61.0	61.0	61.5	62.0	63.0	63.7	63.8	63.8	63.7	63.2
June 26	63.0	62.5	62.0	62.0	62.5	63.5	64.5	65.2	65.7	65.6	65.3	65.0
June 27	64.5	64.0	63.8	63.8	64.5	65.0	66.0	66.7	66.8	66.8	66.7	66.2
June 28	65.5	65.2	65.0	65.0	65.0	65.6	66.0	66.6	66.8	66.8	66.7	66.5
June 29	66.2	66.0	64.5	64.5	64.8	65.2	65.6	65.8	65.9	65.6	65.5	65.3
June 30	65.2	65.0	64.8	64.8	65.0	65.2	65.7	65.7	65.7	65.5	65.3	65.0
July 1	65.0	65.0	65.0	65.6	65.8	66.5	67.0	67.2	67.3	67.0	66.8	66.5
July 2	66.0	66.0	66.0	66.5	67.0	67.8	68.0	68.2	68.2	68.0	67.8	67.6
July 3	67.2	67.0	67.0	67.5	68.0	68.0	68.5	68.6	68.5	68.0	68.0	67.8
July 4	67.5	67.4	67.5	67.5	67.7	67.7	67.8	67.7	67.6	67.0	66.6	65.8
Sum	651.6	649.1	646.6	648.2	651.8	656.5	662.1	665.4	666.3	664.1	662.4	658.9
Average	65.16	64.91	64.66	64.82	65.18	65.65	66.21	66.54	66.63	66.41	66.24	65.89
July 5	65.5	65.0	65.0	65.5	66.5	66.8	67.2	67.5	67.4	67.0	66.7	66.0
July 6	65.8	65.5	65.0	64.0	64.0	64.3	64.8	65.2	65.6	65.5	65.0	64.8
July 7	64.3	64.0	63.7	63.5	63.8	64.3	64.8	65.5	65.6	65.7	65.5	65.2
July 8	65.0	64.5	64.3	64.0	65.0	65.0	65.8	66.5	66.8	66.8	66.7	66.5
July 9	66.0	65.8	65.5	65.5	65.6	65.7	66.5	66.5	66.4	66.2	65.8	65.5
July 10	65.0	65.0	65.0	65.0	65.0	65.2	65.8	66.5	66.5	66.0	66.0	65.8
July 11	65.5	65.0	65.0	65.0	65.4	66.0	66.5	66.8	67.0	67.0	66.8	66.7
July 12	66.0	65.7	65.5	65.5	65.3	65.7	66.0	66.5	66.2	66.0	65.5	65.0
July 13	64.5	64.0	67.5	67.0	67.0	67.5	67.8	68.0	68.0	67.8	67.6	67.0
July 14	66.7	66.0	65.8	65.8	66.0	66.7	67.5	67.8	68.0	68.0	67.7	67.2
Sum	654.3	650.5	652.3	650.8	653.6	657.2	662.7	666.8	667.5	666.0	663.3	659.7
Average	65.43	65.05	65.23	65.08	65.36	65.72	66.27	66.68	66.75	66.60	66.33	65.97
July 15	66.8	66.0	65.8	65.8	66.0	66.8	67.5	68.0	68.0	68.0	67.8	67.5
July 16	66.7	66.5	66.0	66.0	66.5	67.0	68.1	68.8	69.0	69.0	68.7	68.0
July 17	67.8	67.5	67.0	67.0	66.8	66.6	66.5	66.4	66.3	66.0	65.8	65.5
July 18	65.2	65.0	65.0	65.3	65.7	66.0	66.6	67.0	67.0	67.0	66.8	66.5
July 19	66.0	65.7	65.6	65.7	65.8	66.0	66.4	66.6	66.7	66.5	66.0	66.0
July 20	65.7	65.0	66.0	66.0	66.0	66.5	67.0	67.8	67.9	67.8	67.7	67.5
July 21	67.0	66.8	66.7	66.8	67.0	67.2	67.7	67.8	68.0	68.0	67.8	67.5
July 22	67.0	66.5	66.5	66.5	66.7	67.0	68.0	68.5	68.7	68.6	68.5	68.0
July 23	67.8	67.0	67.0	67.0	67.2	67.8	68.6	69.0	69.5	69.5	69.0	69.0
July 24	68.5	68.0	67.8	67.8	68.0	68.5	69.0	69.8	70.0	70.0	70.0	69.6
Sum	668.5	664.0	663.4	663.9	659.7	669.4	675.4	679.7	681.1	680.4	678.1	675.1
Average	66.85	66.40	66.34	66.39	65.97	66.94	67.54	67.97	68.11	68.04	67.81	67.51
July 25	69.0	69.0	68.8	68.8	69.0	69.5	70.0	70.5	70.7	70.8	70.6	70.5
July 26	70.3	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	69.5	69.3
July 27	69.0	68.5	68.5	68.5	68.5	68.6	69.0	69.6	70.0	70.0	69.6	69.5
July 28	69.3	69.0	69.0	69.0	69.7	70.0	70.8	71.0	71.0	71.0	71.0	70.8
July 29	70.5	70.3	70.0	70.0	70.3	70.5	70.6	70.8	71.0	70.8	70.5	70.0
July 30	69.6	69.0	68.7	68.6	68.5	68.6	68.8	69.0	68.8	68.5	68.0	67.5
July 31	67.0	66.5	66.2	66.3	66.7	67.0	67.5	67.7	67.7	67.5	67.0	66.6
August 1	66.5	66.0	66.0	66.0	66.0	66.5	66.8	67.0	67.0	67.0	67.0	66.8
August 2	66.6	66.5	66.5	66.7	67.0	67.8	68.5	69.0	69.2	69.6	69.7	69.7
August 3	69.3	69.0	(*a*)	(*a*)	(*a*)	(*a*)	(*a*)	(*a*)	(*a*)	(*a*)	(*a*)	(*a*)
Sum	687.1	683.8	613.7	613.9	615.7	618.5	621.0	624.6	625.4	625.2	622.9	620.7
Average	68.71	68.38	68.19	68.21	68.44	68.72	69.0	69.4	69.49	69.47	69.21	68.97
August 4 to 9	(*a*)	(*a*)	(*a*)	(*a*)	(*a*)	(*a*)	(*a*)	(*a*)	(*a*)	(*a*)	(*a*)	(*a*)
August 10	(*a*)	(*a*)	69.5	69.0	69.0	69.5	69.8	70.0	70.0	69.6	69.2	69.0
August 11	68.3	68.0	67.5	67.5	67.6	67.8	68.0	68.2	68.2	68.2	68.0	67.5
August 12	67.2	67.0	66.5	66.5	67.0	67.2	67.5	67.8	68.0	67.8	67.5	67.2
August 13	67.0	66.8	66.8	66.8	67.0	67.2	68.0	68.2	68.2	68.2	68.0	67.8
Sum	202.5	201.8	270.3	269.8	270.6	271.7	273.3	274.2	274.4	273.8	272.7	271.5
Average	67.5	67.27	67.58	67.45	67.65	67.93	68.32	68.55	68.60	68.45	68.2	67.88
August 14	67.5	67.2	67.2	67.2	67.5	68.0	68.2	68.5	68.6	68.5	68.2	68.0
August 15	68.0	67.5	67.2	67.2	67.3	67.8	68.0	68.2	68.2	68.2	68.0	68.0
August 16	67.8	67.7	67.5	67.6	68.0	68.2	68.8	69.0	69.2	69.0	69.0	68.7
August 17	68.3	68.0	71.5	71.5	71.2	71.3	72.0	72.2	72.3	72.3	72.0	72.0
August 18	71.5	71.3	71.0	71.0	71.3	72.0	72.3	72.7	73.0	73.0	73.0	73.0
August 19	72.8	72.5	72.3	72.5	72.8	73.0	73.3	73.3	73.3	73.0	72.8	72.3
August 20	72.0	71.5	71.0	71.2	71.5	72.0	72.3	72.7	72.8	72.8	72.5	72.2
August 21	72.0	71.5	71.3	71.3	71.7	72.0	72.2	72.3	72.3	72.3	72.3	72.0

[a] Record blank.

Readings of the soil thermograph at even 2-hour intervals beginning at 6 a. m., under corn on the Miami loam, 1 foot below the surface, at Janesville, Wis., June 8 to September 20, arranged in 10-day periods—1903—Continued.

Date.	Hour of reading.											
	6.	8.	10.	Noon.	2.	4.	6.	8.	10.	M.	2.	4.
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
August 22	72.0	71.8	71.7	71.7	71.8	72.0	72.2	72.7	72.8	72.8	72.8	72.8
August 23	72.8	72.8	72.8	72.8	73.2	73.8	74.2	74.5	74.7	74.7	74.5	74.2
Sum	704.7	701.8	703.5	704.0	706.3	710.1	713.5	716.1	717.2	716.6	715.1	713.2
Average	70.47	70.18	70.35	70.40	70.63	71.01	71.35	71.61	71.72	71.66	71.51	71.32
August 24	74.0	74.0	74.0	75.0	75.0	75.0	75.2	75.3	75.5	75.6	75.5	75.3
August 25	75.2	75.0	75.0	75.0	75.0	75.2	75.4	75.7	75.4	75.2	75.0	74.8
August 26	74.2	74.0	73.8	73.5	73.5	73.5	73.5	73.0	72.8	72.5	72.0	72.0
August 27	71.7	71.3	71.3	71.3	71.3	71.5	71.6	71.7	71.7	71.5	71.3	71.2
August 28	71.0	71.0	71.0	71.0	71.0	71.2	71.3	71.4	71.5	71.6	71.4	71.2
August 29	71.0	71.0	71.0	71.0	71.0	70.8	70.5	70.3	70.0	70.0	70.0	69.5
August 30	69.2	69.0	68.8	68.8	68.8	68.8	68.8	68.8	68.8	68.8	68.5	68.3
August 31	68.2	68.0	63.5	63.5	63.0	63.2	63.3	63.6	63.7	63.8	63.5	63.3
September 1	63.3	62.8	62.5	62.3	62.5	63.0	63.5	64.0	64.2	64.2	64.2	64.0
September 2	64.0	63.6	63.5	63.3	63.5	63.8	64.0	64.5	64.8	65.0	64.8	64.8
Sum	701.8	699.7	694.4	694.7	694.6	696.0	697.1	698.3	698.4	698.2	696.2	694.4
Average	70.18	69.97	69.44	69.47	69.46	69.60	69.71	69.83	69.84	69.82	69.62	69.44
September 3	64.5	64.4	64.2	64.2	64.3	64.8	65.0	65.5	65.8	65.8	65.5	65.3
September 4	65.0	65.0	64.8	64.3	64.2	64.2	64.5	64.6	64.6	64.2	64.0	63.8
September 5	63.5	63.0	63.0	63.0	63.2	63.5	64.0	64.0	64.0	63.8	63.7	63.3
September 6	63.3	62.5	62.0	62.0	62.0	62.0	62.0	62.2	62.2	62.0	62.0	62.0
September 7	62.0	61.8	64.3	64.2	64.3	65.0	65.2	65.7	66.0	66.0	66.0	66.0
September 8	66.0	66.0	66.0	66.3	66.6	67.0	67.5	67.8	68.0	68.0	68.0	68.0
September 9	67.8	67.7	67.5	67.5	67.5	67.5	67.5	67.5	67.5	67.2	67.0	66.8
September 10	66.3	66.0	65.8	65.8	66.0	66.3	66.6	66.8	66.8	66.8	66.5	66.0
September 11	65.7	65.2	65.0	65.2	65.5	66.0	66.2	66.3	66.5	66.7	66.5	66.5
September 12	66.5	66.5	66.8	67.0	67.0	67.3	67.5	68.0	68.0	68.0	68.0	68.0
Sum	650.6	648.1	649.4	649.5	650.6	653.6	656.0	658.4	659.4	658.5	657.2	655.7
Average	65.06	64.81	64.94	64.95	65.06	65.36	65.60	65.84	65.94	65.85	65.72	65.57
September 13	67.8	67.3	67.2	67.2	67.5	67.8	68.0	68.0	68.0	68.2	68.0	68.0
September 14	68.0	68.0	68.0	68.0	68.0	68.2	68.5	68.5	68.5	68.2	68.2	68.0
September 15	68.0	67.8	67.8	67.8	67.8	67.8	68.0	68.0	68.0	67.8	67.5	67.2
September 16	67.0	66.3	66.0	65.3	65.5	64.8	64.3	64.0	63.8	63.4	63.0	62.7
September 17	62.0	61.8	61.5	61.5	61.5	61.5	61.5	61.2	61.0	60.5	60.0	59.7
September 18	59.0	58.8	58.8	58.8	59.0	59.7	60.0	60.0	59.8	59.8	59.5	59.2
September 19	59.0	59.0	59.0	59.3	59.8	60.2	60.5	60.8	60.8	60.8	60.8	60.8
September 20	60.7	60.5	60.8	61.0	61.5	62.0	62.2	62.3	62.3	62.3	62.2	62.0
Sum	511.5	509.5	509.1	508.9	510.6	512.0	513.0	512.8	512.2	511.0	509.2	507.6
Average	63.94	63.69	63.64	63.61	63.83	64.0	64.13	64.1	64.03	63.75	63.65	63.45

Temperature of an Unventilated Shelter 4 Feet above the Surface in a Cornfield on each of 4 Soil Types.

If temperature is an important factor influencing the growth of plants, and if its variations during the season modify the quality of the crop or its yield, the temperatures which influence yield directly must be those within the crop itself. The records which have been presented of the soil temperatures must also be those of the root systems of the crops growing upon the soil. It is not, however, so simple a matter to obtain a knowledge of the internal temperatures of the crop above ground or of its fluctuations. It is clear that the temperature of the air itself in which the crop is immersed can not represent the temperature of the tissues above ground, which must always be a resultant between the effect of conduction by the passing air currents, radiation, and loss of heat by transpiration, and the amounts of heat which may be absorbed from all sources.

The object of the series of records which are here presented was to ascertain whether thermographs, similarly placed at the mean height of the mature corn plants above the surface, and in the corn field, would show relative differences not shown by the soil itself. An unventilated shelter was provided in order to eliminate to some extent the short-period fluctuations of the air itself and to place the thermographs under conditions which would, in a very rough way, represent the interior of the plant.

The shelter used was a cylindrical galvanized iron case, provided with a conical lid with sides having a slope of 20° from the horizontal, and unpainted. The diameter of the shelter was 18 inches; height, exclusive of the cover, 9 inches; and it was supported by a pair of 2 by 4's with its bottom 3 feet above the ground, the thermograph standing in the shelter with the bulb near the north side. The cylindrical form and conical lid were chosen to make the exposure to the sun more nearly uniform throughout the day.

SUMMARY OF FIELD DATA.

In the table which follows there have been brought together the mean temperatures indicated by thermographs placed in unventilated shelters about 4 feet above the ground, freely exposed to sun and wind, except as influenced by the corn plants. The instrument at Goldsboro was placed above the Norfolk sandy soil; the one at Marlboro above the Norfolk sand; the one at Lancaster above the Hagerstown clay loam, and the one at Janesville above the Janesville loam.

Mean air temperatures for 10-day periods 4 feet above the ground in cornfields at 4 stations, as indicated by a Richard thermograph placed in a closed galvanized-iron shelter exposed to the sun and air, except as sheltered by the corn plants—1903.

GOLDSBORO, N. C.

Date.	Hour of reading.											
	6.	8.	10.	Noon.	2.	4.	6.	8.	10.	M.	2.	4.
	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.
May 17 to May 25	66.06	79.37	92.39	97.67	100.5	98.72	84.22	72.79	68.59	64.61	61.53	59.52
May 26 to June 4	63.40	72.10	80.45	85.45	85.65	82.10	77.90	70.30	67.35	64.98	63.83	62.86
June 5 to June 14	65.17	75.05	83.03	86.99	88.27	84.59	77.03	68.31	65.26	63.59	62.24	61.50
June 15 to June 24	64.40	74.83	85.85	91.90	94.37	92.99	87.06	74.38	69.18	66.80	64.24	63.38
June 25 to July 4	70.20	83.35	96.60	103.25	105.60	100.60	89.40	78.20	74.10	71.40	70.18	69.15
July 5 to July 14	72.65	86.31	98.71	105.50	107.40	105.53	88.90	76.45	72.60	70.94	70.01	69.00
July 15 to July 24	69.01	85.78	99.30	107.20	110.30	106.50	90.90	76.35	71.70	79.32	67.65	66.26
July 25 to August 3	72.33	86.25	99.60	105.70	107.90	96.80	85.50	76.70	73.50	71.60	70.38	69.35
August 4 to August 13	70.98	81.80	96.20	107.10	105.70	102.10	86.00	76.60	73.80	72.20	71.00	70.80
August 14 to August 23	67.99	77.10	87.00	96.90	98.90	97.30	83.20	75.40	71.50	69.90	68.60	67.95
August 24 to September 2	70.70	85.10	101.30	108.50	110.80	103.00	94.95	75.35	72.70	70.30	69.50	68.80
September 3 to September 12	62.40	79.70	91.60	97.98	97.80	92.60	76.30	70.20	66.40	64.50	62.50	61.20
September 13 to September 14	63.80	86.00	96.00	98.50	100.00	94.00	75.50	67.50	62.50	59.50	58.00	60.50
General average	67.62	80.98	92.93	99.43	101.01	96.68	84.37	73.73	69.94	68.43	66.13	65.41

Mean air temperatures for 10-day periods 4 feet above the ground in cornfields at 4 stations, as indicated by a Richard thermograph placed in a closed galvanized-iron shelter exposed to the sun and air, except as sheltered by the corn plants—1903—Continued.

Date.	Hour of reading.											
	6.	8.	10.	Noon	2.	4.	6.	8.	10.	M.	2.	4.
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
UPPER MARLBORO, MD.												
June 15 to June 24	61.70	70.40	74.90	78.80	81.90	81.50	74.00	65.90	62.70	62.00	60.22	59.40
June 25 to July 4	69.88	79.20	86.70	91.10	92.50	89.90	83.95	73.40	70.05	69.30	68.40	67.30
July 5 to July 14	67.25	79.90	90.50	96.70	97.20	94.70	85.60	74.20	70.90	67.40	65.60	64.00
July 15 to July 24	61.80	76.70	88.50	94.20	94.30	95.60	85.40	73.40	67.80	65.20	63.10	61.10
July 25 to August 3	64.70	75.70	88.60	92.70	97.50	93.30	82.20	74.50	68.80	68.20	67.40	65.90
August 4 to August 13	65.50	70.40	79.70	86.80	91.20	88.20	80.60	72.30	68.70	67.90	66.70	65.90
August 14 to August 23	62.70	71.80	84.80	89.10	91.30	89.60	78.70	70.10	66.50	65.20	63.97	62.55
August 24 September 2	68.10	73.40	83.70	88.90	94.20	87.30	77.70	72.60	69.90	68.90	68.70	67.80
September 3 to September 12	62.70	70.20	84.80	90.60	92.90	85.90	76.40	68.95	66.10	64.50	63.50	63.10
September 13 to September 20	59.70	67.60	84.80	91.90	92.40	86.60	71.30	63.80	60.90	59.40	58.30	57.37
General average	64.40	73.53	84.70	90.08	92.54	89.26	79.59	70.92	67.24	65.80	64.59	63.44
LANCASTER, PA.												
June 8 to June 14	59.50	65.60	72.40	72.80	77.00	76.30	71.10	64.30	61.10	60.20	59.30	58.60
June 15 to June 24	58.10	65.70	72.60	76.20	78.20	75.70	70.60	64.70	61.90	60.00	58.80	58.20
June 25 to July 4	67.00	75.50	85.20	90.70	92.70	85.98	79.95	71.30	68.30	66.90	65.70	64.70
July 5 to July 14	69.10	84.90	95.60	101.60	96.70	91.20	83.70	73.00	69.40	66.70	64.80	63.30
July 15 to July 24	68.00	83.60	92.10	95.95	94.95	87.90	77.10	67.20	63.40	61.90	60.50	59.30
July 25 to August 3	65.50	84.30	96.40	98.60	96.50	88.20	77.90	69.50	66.30	63.50	60.90	59.50
August 4 to August 13	62.50	74.00	81.60	87.80	89.90	81.90	72.50	66.50	64.60	63.90	61.70	60.30
August 14 to August 23	61.80	73.20	86.80	91.70	91.00	85.20	73.20	66.40	64.20	62.40	61.60	60.40
August 24 to September 2	64.50	69.90	98.90	83.97	84.80	79.80	72.10	67.90	65.90	64.00	63.90	63.30
September 3 to September 12	59.30	70.30	83.70	92.70	91.30	81.30	71.40	65.90	63.80	62.20	60.60	59.30
September 13 to September 20	59.00	74.00	85.20	96.00	91.40	81.80	67.40	61.70	59.10	57.40	55.80	41.80
General average	63.12	74.64	86.41	89.82	89.50	83.21	74.24	67.13	64.36	62.65	61.24	58.97
JANESVILLE, WIS.												
June 1 to June 4	54.83	60.12	64.12	68.62	69.25	67.62	65.95	59.05	56.38	55.13	52.95	52.50
June 5 to June 14	58.70	71.02	77.07	82.18	82.03	80.75	75.43	62.20	56.90	53.88	50.90	49.00
June 15 to June 24	63.65	67.05	84.45	87.95	90.85	85.90	78.80	66.85	60.50	57.28	55.53	54.57
June 25 to July 4	69.13	84.03	94.41	97.93	96.83	94.08	87.78	75.46	68.93	65.96	64.70	64.15
July 5 to July 14	71.93	85.28	93.74	96.48	97.88	94.83	83.93	70.71	65.56	63.38	61.83	50.80
July 15 to July 24	61.13	80.83	89.46	93.48	97.43	94.68	81.71	65.18	59.53	56.43	54.78	54.50
July 25 to August 3	65.18	80.13	87.78	89.28	93.20	88.43	79.13	67.88	64.33	62.60	61.41	60.60
August 4 to August 13	59.23	74.11	82.98	87.03	86.28	80.33	68.58	60.58	57.33	55.58	54.64	54.01
August 14 to August 23	60.68	73.68	89.61	90.33	89.68	82.93	73.63	66.33	63.93	61.93	60.80	59.83
August 24 to September 2	61.34	69.23	76.23	80.33	78.03	72.51	66.08	62.98	61.63	60.63	59.53	58.33
September 3 to September 12	60.23	69.33	69.83	83.03	84.18	68.13	70.03	64.83	63.69	61.78	59.75	58.78
September 13 to September 20	54.70	61.80	72.80	76.54	78.54	72.73	64.73	60.16	58.23	56.48	55.54	54.35
General average	61.73	73.05	81.87	86.10	87.02	81.91	74.65	65.18	61.41	59.26	57.70	55.95

Bringing together the general averages for the 4 cornfields, the results stand as given below:

Mean temperatures in 4 cornfields during the growing season, as indicated by thermographs in unventilated shelters 4 feet above the ground—1903.

Hour of reading.	Goldsboro, N. C.	Upper Marlboro, Md.	Lancaster, Pa.	Janesville, Wis.
	°F.	°F.	°F.	°F.
6 a. m.	67.62	64.40	63.12	61.73
8 a. m.	80.98	73.53	74.64	73.05
10 a. m.	92.93	84.70	86.41	81.87
Noon	99.43	90.08	89.82	86.10
2 p. m.	101.01	92.54	89.50	87.02
4 p. m.	96.68	89.26	83.21	81.91
6 p. m.	84.37	79.59	74.24	74.65
8 p. m.	73.73	70.92	67.13	65.18
10 p. m.	69.94	67.24	64.36	61.41
Midnight	68.43	65.80	62.65	59.26
2 a. m.	66.13	64.59	61.24	57.70
4 a. m.	65.41	63.44	58.97	55.95
Mean for 24 hours	80.56	75.51	72.94	70.49

From this table it will be seen that the highest daily temperatures occur near 2 p. m. and the lowest near 4 a. m. The differences between the maximum and minimum temperatures at the 4 stations are expressed in the next table:

Maximum and minimum temperatures in cornfields at the 4 stations, and excess of temperatures at the other 3 stations over those at Janesville, which were the lowest—1903.

	Goldsboro, N. C.	Upper Marlboro, Md.	Lancaster, Pa.	Janesville, Wis.
	°F.	°F.	°F.	°F.
Maximum temperatures	101.01	92.54	89.50	87.02
Excess	13.99	5.52	2.48	.00
Minimum temperature	65.41	63.44	58.97	55.95
Excess	9.46	7.49	3.02	.00

It will be seen that the differences between the maximum temperatures at the 4 stations have very nearly the same values as those shown by the soil temperatures; but the minimum temperature at Goldsboro was not, relatively, as much higher.

From these records it appears that the climatic conditions at Goldsboro are such that they tend to develop a temperature, both in the root system and in the plant above ground, 12° to 14° F. higher than at Janesville. It is probable, moreover, that transpiration from the plant prevents such large differences in the plant above ground ever occurring, but the influence must be there to affect the rate of transpiration and of growth as well, so far as the temperature is not controlled by the transpiration.

THE FIELD DATA IN DETAIL.

The following are the field data of this series of records:[a]

Records from air thermograph in closed galvanized-iron shelters stationed in field of corn at Goldsboro, N. C., May 17 to September 14, arranged in 10-day periods—1903.

Date.	Hour of reading.											
	6.	8.	10.	Noon.	2.	4.	6.	8.	10.	M.	2.	4.
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
May 17	39.0	42.0	55.0	66.0	74.0	77.0	75.5	61.0	49.0	41.0	36.3	34.2
May 18	33.0	42.0	75.0	82.5	85.0	85.0	68.5	53.0	46.5	42.0	38.5	36.0
May 19	43.0	64.5	82.0	87.5	87.0	84.0	69.0	55.0	49.5	49.0	45.5	42.0
May 20	52.0	68.5	78.0	83.0	87.0	85.0	70.0	61.0	56.5	51.5	47.5	46.0
May 21	54.0	68.0	84.0	86.5	88.5	85.0	65.0	60.0	59.0	52.0	49.5	49.0
May 22	59.0	71.8	83.0	88.0	89.5	85.0	73.0	66.0	62.5	57.0	52.0	50.0
May 23	64.0	82.5	86.0	87.5	89.0	86.5	71.5	52.5	51.0	48.0	47.5	46.0
May 24	59.0	73.5	82.0	89.0	92.5	88.0	65.0	52.0	50.2	50.0	48.5	47.0
May 25	54.0	62.0	67.0	69.5	72.5	73.5	61.0	56.0	53.5	51.5	48.5	46.0
Sum	455.0	574.8	692.0	739.5	765.0	749.0	618.5	516.5	477.7	442.0	414.3	396.2
Corrected sum[b]	594.5	714.3	831.5	879.0	904.5	888.5	758.0	656.0	617.2	581.5	553.8	535.7
Average	66.06	79.37	92.39	97.67	100.5	98.72	84.22	72.79	68.59	64.61	61.53	59.52
May 26	46.0	48.5	56.0	68.0	71.0	63.5	62.0	56.5	54.5	53.0	52.0	51.8
May 27	52.0	60.0	71.0	75.0	78.0	74.0	67.0	58.0	53.5	52.5	50.0	48.5
May 28	49.5	58.0	67.0	75.5	78.0	76.0	68.0	60.0	56.0	54.0	53.8	50.5
May 29	51.0	57.0	63.0	82.0	75.5	70.0	67.5	57.0	52.5	51.0	50.0	49.0
May 30	51.0	64.0	73.0	80.0	85.0	82.0	74.0	61.0	55.5	51.0	48.5	48.0
May 31	50.0	64.0	81.0	82.0	78.0	60.0	55.0	52.0	52.0	48.0	46.0	45.0
June 1	44.0	46.0	47.5	48.0	50.0	49.5	48.0	45.5	44.0	43.8	43.0	42.8
June 2	42.5	48.0	56.0	62.0	60.0	56.5	56.5	50.5	49.0	46.0	45.0	44.0
June 3	44.0	51.0	61.0	65.5	62.0	64.5	61.0	51.0	47.0	45.0	45.0	44.0
June 4	49.0	69.5	74.0	61.5	65.0	70.0	65.0	56.5	54.5	50.5	50.0	50.0
Sum	479.0	566.0	649.5	699.5	701.5	666.0	624.0	548.0	518.5	494.8	483.3	473.6
Corrected sum[b]	634.0	721.0	804.5	854.5	856.5	821.0	779.0	703.0	673.5	649.8	638.3	628.6
Average	63.40	72.10	80.45	85.45	85.65	82.10	77.90	70.30	67.35	64.98	63.83	62.86
June 5	50.7	54.5	61.0	62.6	62.5	63.0	58.5	55.0	51.5	50.8	51.0	50.0
June 6	52.5	64.0	65.3	65.5	62.0	60.5	57.3	53.1	52.0	52.8	53.5	53.0
June 7	53.0	58.0	69.0	66.0	62.0	65.0	58.5	54.5	52.5	51.5	50.8	49.5
June 8	55.0	64.5	70.5	80.8	81.0	80.5	77.5	62.0	56.0	53.0	53.5	53.5
June 9	54.0	60.0	75.0	82.5	85.0	77.0	60.0	55.5	52.0	51.0	50.0	50.5
June 10	52.5	70.0	81.5	86.0	88.0	71.0	57.0	57.0	52.0	49.0	48.8	49.0
June 11	54.5	55.0	73.0	76.0	80.0	73.0	57.5	54.0	53.0	51.8	48.5	47.0
June 12	46.0	51.0	56.5	63.0	66.5	60.8	55.0	42.5	40.8	37.0	33.0	33.0
June 13	38.5	50.5	59.0	63.5	68.5	70.0	59.0	41.5	38.0	35.0	32.5	31.5
June 14	40.0	58.0	64.5	69.0	72.2	70.1	65.0	53.0	49.8	49.0	45.8	43.0
Sum	496.7	595.5	675.3	714.9	727.7	690.9	615.3	528.1	497.6	480.9	467.4	460.0
Corrected sum[b]	651.7	750.5	830.3	869.9	882.7	845.9	770.3	683.1	652.6	635.9	622.4	615.0
Average	65.17	75.05	83.03	86.99	88.27	84.59	77.03	68.31	65.26	63.59	62.24	61.50
June 15	50.0	60.0	66.5	69.5	72.0	74.0	70.0	53.0	44.0	41.5	39.0	37.5
June 16	38.0	53.0	66.0	72.0	76.0	74.0	69.0	55.0	47.0	45.0	42.6	41.0
June 17	43.0	60.5	74.0	79.0	84.0	84.8	74.1	59.0	57.5	55.0	49.5	47.5
June 18	47.0	54.0	68.0	77.5	82.0	88.0	72.0	59.5	50.5	46.0	44.5	42.3
June 19	45.0	63.0	78.5	84.5	85.2	84.0	71.5	61.8	58.0	55.0	54.0	55.0
June 20	56.5	65.5	76.0	80.0	76.5	76.8	74.0	66.0	61.5	60.0	55.0	53.5
June 21	55.5	67.0	76.5	81.5	85.5	87.8	80.0	63.0	58.5	53.5	49.5	49.5
June 22	51.0	58.0	72.0	82.0	83.5	60.5	62.0	54.5	52.5	52.5	50.5	49.0
June 23	49.5	54.5	65.0	74.0	81.0	85.0	83.0	62.5	53.8	52.0	51.8	52.5
June 24	53.5	57.8	61.0	64.0	63.0	60.0	60.0	54.5	53.5	52.5	51.0	51.0
Sum	489.0	593.3	703.5	764.0	788.7	774.9	715.6	588.8	536.8	513.0	4[illegible]7.4	478.8
Corrected sum[b]	644.0	748.3	858.5	919.0	943.7	929.9	870.6	743.8	691.8	668.0	642.4	633.8
Average	64.40	74.83	85.85	91.90	94.37	92.99	87.06	74.38	69.18	66.80	64.24	63.38
June 25	50.0	51.0	68.0	73.0	84.0	85.0	78.0	64.0	60.5	53.0	52.0	51.0
June 26	51.5	59.0	75.0	83.0	79.5	73.0	57.0	53.5	52.5	51.0	50.5	49.5
June 27	51.0	62.0	71.0	79.0	85.0	84.0	75.5	64.5	60.0	57.0	56.0	54.5
June 28	55.5	70.0	77.0	83.5	83.0	62.0	58.5	53.0	51.5	51.5	51.5	52.4
June 29	53.5	59.5	69.0	76.0	80.5	84.5	81.0	64.0	56.0	53.5	52.8	50.5
June 30	51.0	69.0	86.0	93.5	95.5	95.0	86.5	66.0	60.0	57.0	55.5	53.5
July 1	55.0	74.0	90.0	96.5	97.5	94.0	80.5	67.0	62.5	59.5	57.0	56.0
July 2	57.5	73.0	88.0	95.0	98.0	95.0	82.0	68.0	62.5	60.0	58.0	57.0
July 3	60.0	80.0	93.0	98.0	99.0	91.5	77.0	69.0	63.5	60.5	59.0	57.5
July 4	62.0	81.0	94.0	100.0	99.0	87.0	63.0	58.0	57.0	56.0	54.5	54.2
Sum	547.0	678.5	811.0	877.5	901.0	851.0	739.0	627.0	586.0	559.0	546.8	536.5
Corrected sum[b]	702.0	833.5	966.0	1032.5	1056.0	1006.0	894.0	782.0	741.0	714.0	701.8	691.5
Average	70.20	83.35	96.60	103.25	105.60	100.60	89.40	78.20	74.10	71.40	70.18	69.15

[a] As the record sheets available were only graduated to 100° F., the pen had to be set low in order to get the record on the sheet. The data are given as taken from the the sheets, and the corrections are made in the sums.

[b] Correction here is 15.5° on all readings.

Records from air thermograph in closed galvanized-iron shelters stationed in field of corn at Goldsboro, N. C., May 17 to September 14, arranged in 10-day periods—1903—Cont'd.

Date.	Hour of reading.											
	6.	8.	10.	Noon.	2.	4.	6.	8.	10.	M.	2.	4.
	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*
July 5	58.5	71.8	79.8	81.0	89.5	93.0	76.5	65.0	62.5	58.7	58.0	57.8
July 6	59.5	65.0	83.0	94.0	98.0	97.0	66.0	58.5	56.5	56.0	56.0	56.0
July 7	56.0	63.0	73.5	80.0	84.0	86.0	77.0	64.0	57.0	54.0	51.0	48.2
July 8	50.0	70.0	84.0	92.0	94.5	97.0	75.0	55.5	49.7	49.2	48.5	49.0
July 9	53.5	76.0	91.0	96.5	102.0	102.5	81.0	63.0	58.0	56.0	54.5	53.5
July 10	57.5	78.0	90.0	97.5	99.0	93.3	79.5	66.5	62.5	60.0	59.0	58.0
July 11	62.0	79.0	91.0	96.5	99.5	94.0	79.0	68.0	64.5	62.0	60.5	58.0
July 12	63.0	79.0	90.0	96.0	84.0	91.0	75.0	63.0	60.0	60.0	60.5	60.5
July 13	62.0	66.5	76.8	84.0	86.0	61.5	53.5	52.0	51.8	51.5	51.5	50.0
July 14	49.5	59.8	73.0	83.0	82.5	85.0	71.5	54.0	48.5	47.0	45.6	44.0
Sum	571.5	708.1	832.1	900.5	919.0	900.3	734.0	609.5	571.0	554.4	545.1	535.0
Corrected sum[a]	726.5	863.1	987.1	1055.5	1074.0	1055.3	889.0	764.5	726.0	709.4	700.1	690.0
Average	72.65	86.31	98.71	105.5	107.4	105.53	88.90	76.45	72.6	70.94	70.01	69.0
July 15	45.0	64.0	79.0	87.5	89.0	88.0	70.0	54.5	49.5	46.5	44.5	43.0
July 16	44.8	58.0	70.0	80.0	91.0	86.0	70.0	54.5	52.5	52.2	51.0	50.8
July 17	51.5	58.0	72.0	86.5	93.5	92.0	75.0	59.0	54.5	52.5	51.0	48.2
July 18	51.8	71.0	85.0	88.0	92.0	89.0	75.5	66.5	62.5	61.0	60.0	58.5
July 19	60.0	77.5	86.0	99.5	96.0	88.0	79.0	65.0	61.0	59.0	57.0	55.0
July 20	58.0	75.0	90.0	99.0	100.0	97.8	80.0	61.0	54.0	51.0	48.5	46.6
July 21	50.0	70.0	88.0	98.5	103.0	100.0	80.0	62.0	59.5	56.0	55.0	54.0
July 22	59.0	80.0	93.0	95.0	101.0	96.5	80.0	67.5	63.0	61.0	60.0	60.0
July 23	62.0	74.8	92.0	94.5	90.0	85.5	73.0	60.5	53.0	50.0	47.5	46.0
July 24	53.0	74.5	83.0	89.0	93.0	87.0	71.5	58.0	52.5	49.0	47.0	45.5
Sum	535.1	702.8	838.0	917.5	948.5	909.8	754.0	608.5	562.0	538.2	521.5	507.6
Corrected sum[a]	690.1	857.8	993.0	1072.5	1103.5	1064.8	909.0	763.5	717.0	793.2	676.5	662.6
Average	69.01	85.78	99.30	107.2	110.3	106.5	90.90	76.35	71.70	79.32	67.65	66.26
July 25	56.0	82.0	99.0	102.0	103.0	96.0	73.0	62.5	57.5	53.0	51.0	49.5
July 26	60.0	80.0	94.5	101.0	106.0	98.0	88.0	67.0	62.5	60.0	57.0	53.5
July 27	62.0	74.0	88.5	99.0	105.0	84.0	78.0	66.5	59.0	57.5	54.5	52.0
July 28	50.5	62.5	70.0	79.0	89.0	79.0	70.0	61.0	58.5	56.5	56.0	56.0
July 29	57.5	70.0	84.5	91.5	92.5	86.0	75.0	65.0	61.0	59.0	57.5	57.0
July 30	59.0	76.5	92.5	98.5	95.0	92.0	65.0	58.0	56.0	56.0	55.5	55.5
July 31	59.5	75.5	88.0	88.0	94.5	68.0	59.0	56.5	55.5	54.5	53.0	52.0
August 1	55.0	70.0	93.0	94.0	83.0	62.5	57.0	56.0	55.0	53.5	52.8	52.5
August 2	53.0	55.0	62.0	66.5	68.0	66.0	61.5	58.0	55.5	55.0	55.5	55.5
August 3	55.8	62.0	69.0	83.0	88.5	81.5	73.5	61.5	59.5	56.0	56.0	55.0
Sum	568.3	707.5	841.0	902.5	924.5	813.0	700.0	612.0	580.0	561.0	548.8	538.5
Corrected sum[a]	723.3	862.5	996.0	1057.5	1079.5	968.0	855.0	767.0	735.0	716.0	703.8	693.5
Average	72.33	86.25	99.6	105.7	107.9	96.80	85.50	76.70	73.50	71.60	70.38	69.35
August 4	53.0	66.0	87.0	87.5	91.0	87.5	71.5	61.0	57.5	55.0	55.0	56.0
August 5	56.2	68.0	88.5	98.0	101.0	100.0	82.0	67.3	61.5	59.0	57.0	56.5
August 6	55.6	70.5	93.0	99.0	100.0	88.5	63.0	59.0	56.5	55.0	54.1	53.5
August 7	54.0	69.5	83.5	92.0	101.0	100.0	80.0	63.0	59.0	57.0	54.5	53.5
August 8	54.5	62.0	81.0	92.0	90.0	73.0	67.0	61.5	61.0	60.5	59.0	58.0
August 9	59.0	67.0	73.0	85.0	92.0	94.0	77.0	64.5	62.0	60.5	59.5	59.0
August 10	59.5	72.0	90.0	99.0	101.0	95.0	78.0	65.0	61.0	58.0	57.0	55.8
August 11	56.0	74.0	80.0	97.5	90.0	84.0	59.5	55.5	54.5	54.0	53.0	53.0
August 12	54.0	57.0	62.0	82.0	68.0	69.0	64.0	56.5	54.0	53.0	52.2	53.0
August 13	53.0	57.0	69.0	83.5	68.0	75.3	63.0	58.0	56.0	55.0	54.0	55.0
Sum	554.8	663.0	807.0	915.5	902.0	866.3	705.0	611.3	583.0	567.0	555.3	553.3
Corrected sum[a]	709.8	818.0	962.0	1070.5	1057.0	1021.3	860.0	766.3	738.0	722.0	710.3	708.3
Average	70.98	81.8	96.2	107.1	105.7	102.1	86.0	76.6	73.8	72.2	71.0	70.8
August 14	55.0	69.0	81.0	89.0	94.2	99.0	75.0	63.5	60.0	59.0	57.5	57.0
August 15	56.0	56.5	60.0	79.5	83.0	79.0	66.0	59.0	56.0	54.5	54.2	54.0
August 16	54.5	57.0	70.0	86.0	91.0	78.0	64.5	57.5	55.8	53.5	51.5	51.0
August 17	51.5	58.0	65.0	75.0	80.5	81.0	69.5	57.5	53.8	52.0	50.0	49.2
August 18	48.0	59.0	74.5	82.0	64.0	66.0	67.5	67.5	55.0	53.5	52.0	52.5
August 19	52.7	55.0	58.0	63.0	68.0	72.5	60.0	57.5	56.5	56.5	56.5	56.0
August 20	56.2	57.1	60.0	70.0	71.8	65.5	63.5	58.0	54.5	53.0	51.0	50.0
August 21	49.0	60.0	73.5	81.6	86.5	88.6	68.0	54.0	51.0	49.5	47.5	46.0
August 22	47.0	70.0	85.0	90.2	94.0	91.5	70.0	60.0	57.5	55.0	54.0	53.8
August 23	55.0	74.0	88.0	97.5	101.0	96.5	73.0	64.0	60.0	57.5	56.5	55.0
Sum	524.9	615.6	719.0	813.8	834.0	877.6	677.0	598.5	560.1	544.0	530.7	524.5
Corrected sum[a]	679.9	770.6	870.0	968.8	989.0	972.6	832.0	753.5	715.1	699.0	685.7	679.5
Average	67.99	77.1	87.0	96.9	98.9	97.3	83.2	75.4	71.5	69.9	68.6	67.95
August 24	55.5	69.0	88.0	97.5	101.0	99.5	81.0	60.5	55.5	52.5	51.8	51.0
August 25	51.0	70.0	91.0	100.0	104.0	103.0	81.0	65.0	62.5	60.5	60.0	58.0
August 26	58.0	78.0	95.0	103.0	104.5	104.0	80.0	66.0	64.0	59.0	57.2	56.5
August 27	58.0	79.0	90.0	99.5	101.0	72.0	60.0	56.0	55.0	54.0	55.5	57.0

[a] Correction 15.5° on all readings (see explanation in footnote, p. 156).

Records from air thermograph in closed galvanized-iron shelter stationed in field of corn at Goldsboro, N. C., May 17 to September 14, arranged in 10-day periods—1903—Cont'd.

Date.	Hour of reading.											
	6.	8.	10.	Noon.	2.	4.	6.	8.	10.	M.	2.	4.
	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*
August 28	58.0	70.0	91.0	101.0	108.0	98.5	75.0	64.0	61.5	60.5	59.0	57.0
August 29	57.0	84.5	100.0	105.0	110.0	100.0	75.0	65.0	60.5	58.2	57.0	58.0
August 30	60.0	70.0	85.0	88.5	88.8	77.0	63.0	59.5	58.0	56.0	53.5	52.0
August 31	54.0	60.0	78.0	82.5	81.0	76.0	63.0	57.0	53.0	50.0	48.0	47.5
September 1	49.5	59.5	69.5	79.0	87.0	75.0	57.0	53.0	51.5	49.0	50.0	50.5
September 2	51.0	56.0	70.0	73.5	74.0	70.0	59.5	52.5	50.5	48.0	48.0	45.5
Sum	552.0	696.0	857.5	929.5	959.3	875.0	794.5	597.5	572.0	547.7	540.0	533.3
Corrected sum [a]	707.0	851.0	1012.5	1084.5	1108.3	1030.0	949.5	758.5	727.0	702.7	695.0	688.0
Average	70.7	85.1	101.3	108.5	110.8	103.0	94.95	75.35	72.7	70.3	69.5	68.8
September 3	47.0	64.0	75.0	78.5	79.2	75.0	60.0	54.5	50.0	48.0	47.5	45.5
September 4	46.0	59.0	68.5	73.6	74.0	66.5	57.0	50.0	48.0	45.5	45.2	45.8
September 5	46.0	55.0	74.5	79.5	83.0	82.0	60.0	50.0	48.0	46.8	45.5	44.0
September 6	50.0	68.0	80.0	84.5	80.0	72.0	60.0	56.0	55.0	53.0	51.0	49.7
September 7	47.8	59.0	69.0	79.0	78.5	72.0	62.5	57.0	53.5	52.0	47.0	43.5
September 8	43.8	59.0	73.0	84.0	85.0	78.5	65.5	57.5	53.0	52.2	51.0	51.0
September 9	51.0	69.0	81.5	86.0	84.0	83.0	63.0	56.0	51.5	50.0	47.5	46.0
September 10	46.0	69.0	81.5	89.2	87.0	81.0	64.0	56.5	52.8	50.0	47.6	46.0
September 11	46.0	68.0	75.0	86.0	87.0	81.0	62.5	54.5	49.0	46.5	45.0	43.5
September 12	45.0	71.5	82.5	84.5	85.0	79.5	63.0	51.5	48.5	45.5	43.0	42.0
Sum	468.6	641.5	760.5	824.8	822.7	770.5	617.5	546.5	509.3	489.5	470.3	457.0
Corrected sum [a]	623.6	796.5	915.5	979.8	977.7	925.5	762.5	701.5	664.3	644.5	625.3	612.0
Average	62.4	79.7	91.6	97.98	97.8	92.6	76.3	70.2	66.4	64.5	62.5	61.2
September 13	49.0	70.0	79.0	83.0	84.5	78.5	60.0	52.0	47.0	44.0	42.5	45.0
September 14	47.5	71.0	82.0	......	......	......	......	......	......	......	......	......
Sum	96.5	141.0	161.0	83.0	84.5	78.5	60.0	52.0	47.0	44.0	42.5	45.0
Corrected sum [a]	127.5	172.0	192.0	98.5	100.0	94.0	75.5	67.5	62.5	59.5	58.0	60.5
Average	63.8	86.0	96.0	98.5	100.0	94.0	75.5	67.5	62.5	59.5	58.0	60.5

[a] Correction 15.5° on all readings (see explanation in footnote, p. 156).

Records from air thermograph in closed galvanized-iron shelter stationed in field of corn at Upper Marlboro, Md., June 15 to September 20, arranged in 10-day periods—1903.

Date.	Hour of reading.											
	6.	8.	10.	Noon.	2.	4.	6.	8.	10.	M.	2.	4.
	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*
June 15	......	......	45.0	50.5	52.2	55.7	51.8	44.5	43.2	40.8	38.8	36.5
June 16	40.0	50.0	60.5	66.5	69.0	63.5	50.0	43.7	43.7	42.2	40.2	39.0
June 17	41.0	48.0	49.2	52.0	53.5	49.5	47.3	44.5	44.0	43.7	42.5	38.5
June 18	38.5	47.7	56.0	61.5	64.7	64.7	59.3	43.0	37.0	36.0	33.3	34.3
June 19	39.5	53.0	64.5	71.3	73.5	73.5	57.2	49.2	45.5	43.8	43.6	43.2
June 20	45.0	56.5	54.5	52.5	61.8	68.0	56.0	49.0	45.0	43.0	40.0	38.8
June 21	42.5	51.0	59.0	62.5	65.0	63.0	60.0	45.0	38.0	......	......	......
June 22	44.0	58.0	64.0	67.8	68.0	65.5	55.0	47.5	43.0	42.0	40.0	40.0
June 23	41.8	42.5	44.5	50.0	52.5	52.0	50.5	45.5	43.5	43.6	41.6	42.0
June 24	42.5	47.0	52.0	53.0	59.0	59.5	53.0	47.0	44.5	43.0	42.0	41.8
Sum	374.8	453.7	549.2	587.6	619.2	614.9	540.1	458.9	427.4	378.1	362.0	354.1
Corrected sum [a]	554.8	633.7	749.2	787.6	819.2	814.9	740.1	658.9	627.4	558.1	542.0	534.1
Average	61.7	70.4	74.9	78.8	81.9	81.5	74.0	65.9	62.7	62.0	60.22	59.4
June 25	41.5	43.7	53.0	54.0	60.0	60.0	57.0	48.0	44.0	46.0	46.0	46.0
June 26	47.0	52.0	51.5	58.5	65.0	62.0	55.0	49.5	45.0	44.5	43.5	43.0
June 27	44.5	48.5	49.0	58.5	70.5	66.5	62.0	51.0	48.0	47.0	46.0	46.5
June 28	47.0	53.0	64.0	66.0	61.0	60.0	54.0	52.5	52.0	50.5	50.2	50.0
June 29	50.8	59.5	64.0	63.5	63.0	69.5	62.5	51.0	45.0	43.5	43.0	43.0
June 30	45.5	52.0	65.5	76.8	79.0	72.5	68.0	55.5	50.0	48.0	46.5	44.8
July 1	50.5	69.0	79.5	83.5	84.0	82.5	74.5	57.5	56.5	57.5	55.0	52.0
July 2	59.0	71.0	81.0	84.5	87.0	86.5	77.5	60.5	55.5	53.0	52.5	50.0
July 3	58.0	73.5	83.5	81.5	88.0	85.0	74.0	56.0	54.0	53.2	51.5	51.0
July 4	55.0	70.0	76.2	84.5	67.0	54.5	55.0	52.5	51.0	50.0	49.5	47.0
Sum	498.8	592.2	667.2	711.3	724.5	699.0	639.5	534.0	500.5	493.2	483.7	473.3
Corrected sum [a]	698.8	792.2	867.2	911.3	924.5	899.0	839.5	734.0	700.5	693.2	683.7	673.3
Average	69.88	79.2	86.7	91.1	92.5	89.9	83.95	73.4	70.05	69.3	68.4	67.3
July 5	50.0	61.5	69.0	71.5	71.0	71.0	60.0	54.0	52.8	50.0	49.0	48.5
July 6	50.0	60.0	70.0	76.5	80.0	74.0	66.0	58.0	63.5	48.5	44.0	40.0
July 7	44.5	60.0	69.0	73.5	78.0	78.0	71.5	52.0	46.0	44.0	41.5	39.5

[a] Correction 20° on all readings (see explanation in footnote, p. 156).

Records from air thermograph in closed galvanized-iron shelter stationed in field of corn at Upper Marlboro, Md., June 15 to September 20, arranged in 10-day periods—1903—Con.

Date.	Hour of reading.											
	6.	8.	10.	Noon.	2.	4.	6.	8.	10.	M.	2.	4.
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
July 8	45.0	64.0	75.0	81.0	83.0	82.5	76.0	55.0	48.0	46.0	46.0	45.0
July 9	48.0	65.0	76.0	87.0	86.0	83.0	77.0	58.5	50.5	46.5	45.0	45.5
July 10	47.5	62.0	78.0	84.8	86.0	87.5	73.0	60.0	55.0	52.0	52.0	50.0
July 11	51.0	70.0	79.8	86.0	87.0	89.2	61.0	52.0	50.0	49.0	47.5	47.0
July 12	49.0	60.0	76.0	83.0	74.0	54.0	53.0	51.0	50.0	49.0	47.0	47.0
July 13	46.5	45.5	48.0	55.0	57.0	54.0	51.5	48.5	47.5	46.5	45.0	42.0
July 14	41.0	51.0	64.0	69.0	70.0	73.5	67.0	53.0	46.0	42.0	39.1	35.5
Sum	472.5	599.0	704.8	767.3	772.0	746.7	656.0	542.0	509.3	473.5	456.1	440.0
Corrected sum [a]	672.5	799.0	904.8	967.3	972.0	946.7	856.0	742.0	709.3	673.5	656.1	640.0
Average	67.25	79.9	90.5	96.7	97.2	94.7	85.6	74.2	70.9	67.4	65.6	64.0
July 15	35.0	52.0	60.0	64.0	63.0	64.0	57.5	43.0	36.0	34.5	32.0	31.6
July 16	31.0	49.0	61.5	70.0	72.0	71.0	63.0	50.0	41.5	40.0	35.5	33.5
July 17	34.0	52.0	72.0	78.0	77.0	79.0	70.0	55.0	48.6	49.0	47.5	47.0
July 18	48.5	50.0	52.0	54.5	64.0	74.0	73.0	64.0	60.0	55.0	50.5	46.5
July 19	45.5	59.0	62.0	72.0	76.0	78.5	71.0	58.0	48.0	45.0	44.0	47.5
July 20	43.5	49.0	80.0	82.5	69.0	77.5	58.5	52.0	47.5	43.0	43.0	40.0
July 21	43.0	63.0	72.0	77.0	80.0	87.0	66.0	50.5	46.5	45.5	47.6	46.0
July 22	48.0	68.0	77.5	85.0	82.0	75.0	61.0	55.5	54.0	49.8	45.5	42.5
July 23	44.0	61.0	72.0	76.5	76.5	73.0	64.5	51.0	46.5	45.0	43.0	42.0
July 24	45.0	64.0	76.0	82.0	83.0	77.0	69.0	55.0	49.0	45.0	42.0	40.0
Sum	417.5	567.0	685.0	741.5	742.5	756.0	653.5	534.0	477.6	451.8	430.6	416.6
Corrected sum [a]	617.5	767.0	885.0	941.5	942.5	956.0	853.5	734.0	677.6	651.8	630.6	610.6
Average	61.8	76.7	88.5	94.2	94.3	95.6	85.4	73.4	67.8	65.2	63.1	61.1
July 25	40.5	65.0	82.0	86.0	92.0	83.0	70.5	56.5	51.8	53.5	51.5	47.0
July 26	45.5	65.0	82.0	86.0	90.0	85.5	74.5	66.0	58.0	59.0	57.0	53.5
July 27	49.0	60.0	67.0	70.0	75.0	70.2	61.5	46.0	39.5	37.5	35.0	32.0
July 28	33.0	50.0	70.0	74.5	81.0	76.5	63.0	51.0	46.0	45.5	47.0	49.0
July 29	50.0	60.5	75.0	80.0	87.0	80.5	64.0	60.0	54.5	52.5	51.0	51.0
July 30	51.5	61.0	77.0	81.8	88.2	86.0	61.0	56.0	51.5	51.0	51.5	49.0
July 31	48.0	58.0	62.5	60.0	57.0	57.0	51.5	47.5	45.0	43.2	42.0	41.5
August 1	41.8	42.5	45.5	47.5	47.5	48.0	46.0	45.0	42.5	41.5	42.0	42.0
August 2	42.0	44.5	55.0	65.0	75.0	71.0	65.0	62.0	47.0	47.0	46.5	46.0
August 3	46.0	50.0	70.0	76.5	82.0	75.0	65.0	55.0	52.5	51.5	50.0	48.0
Sum	447.3	556.5	686.0	727.3	774.7	732.7	622.0	545.0	488.3	482.2	473.5	459.0
Corrected sum [a]	647.3	756.5	886.0	927.3	974.7	932.7	822.0	745.0	688.3	682.2	673.5	659.0
Average	64.7	75.7	88.6	92.7	97.5	93.3	82.2	74.5	68.8	68.2	67.4	65.9
August 4	47.5	49.0	53.0	60.0	63.0	57.0	57.0	53.5	51.5	50.0	47.5	47.5
August 5	49.0	53.0	65.0	76.0	79.0	79.5	70.0	55.0	50.0	49.0	50.0	49.0
August 6	48.0	49.5	52.0	54.2	64.0	64.5	60.5	55.5	52.0	51.2	48.0	45.0
August 7	42.5	50.0	61.5	69.0	74.0	71.5	61.0	47.5	40.5	38.0	35.5	34.0
August 8	32.6	43.0	61.0	70.5	73.0	67.0	59.5	53.0	50.0	49.0	49.0	48.5
August 9	48.6	50.0	55.5	61.5	75.0	80.0	69.0	60.0	52.5	49.5	49.0	48.5
August 10	46.5	50.5	65.0	79.0	87.2	79.0	65.0	54.8	54.8	55.0	52.0	52.0
August 11	52.5	57.5	60.0	65.0	63.5	61.5	60.0	51.5	49.5	50.0	49.0	45.5
August 12	44.5	54.5	70.0	73.5	76.0	69.0	55.0	46.0	41.5	41.0	40.0	41.5
August 13	43.0	47.2	54.0	59.0	57.0	52.5	49.0	46.5	45.0	46.0	47.0	47.8
Sum	454.7	504.2	597.0	667.7	711.7	681.5	606.0	522.8	487.3	478.7	467.0	459.3
Corrected sum [a]	654.7	704.2	797.0	867.7	911.7	881.5	806.0	722.8	687.3	678.7	667.0	659.3
Average	65.5	70.4	79.7	86.8	91.2	88.2	80.6	72.3	68.7	67.9	66.7	65.9
August 14	48.0	49.0	48.0	50.0	50.0	50.0	47.6	46.5	46.0	45.0	44.5	45.0
August 15	46.5	54.5	65.0	72.5	75.0	68.0	57.5	50.0	46.5	47.0	46.0	44.0
August 16	43.0	45.0	55.0	62.0	64.0	60.0	52.5	48.0	47.0	46.0	45.0	43.5
August 17	42.0	51.0	66.0	70.0	66.0	70.5	56.0	47.0	42.5	40.0	38.0	36.5
August 18	38.0	51.0	69.0	70.0	75.5	68.0	58.5	51.0	46.0	46.0	44.2	43.0
August 19	43.5	56.0	64.0	62.0	58.0	60.0	58.0	52.5	51.0	51.0	50.0	49.5
August 20	49.0	54.5	57.5	67.0	65.5	68.5	59.0	49.0	45.0	41.0	38.0	35.0
August 21	35.0	48.0	70.0	72.5	83.0	80.0	60.0	46.0	40.0	38.0	37.5	36.0
August 22	36.5	51.0	74.0	82.0	86.5	83.0	69.0	55.0	50.0	49.0	49.0	47.0
August 23	45.0	58.0	79.5	83.0	89.0	87.5	69.0	56.0	51.0	49.0	47.5	46.0
Sum	426.5	518.0	648.0	691.0	712.5	695.5	587.1	501.0	465.0	452.0	439.7	425.5
Corrected sum [a]	626.5	718.0	848.0	891.0	912.5	895.5	787.1	701.0	665.0	652.0	639.7	625.5
Average	62.7	71.8	84.8	89.1	91.3	89.6	78.7	70.1	66.5	65.2	63.97	62.55
August 24	45.5	55.0	79.0	87.0	93.0	86.0	68.0	56.5	53.0	53.0	53.0	51.2
August 25	51.0	65.0	85.0	91.5	96.5	90.5	71.5	64.0	58.0	53.2	55.0	52.0
August 26	52.5	64.5	78.5	78.0	85.0	75.0	64.5	58.5	56.8	55.0	55.0	53.5
August 27	53.6	57.0	68.0	69.0	69.0	61.5	55.5	54.0	52.0	52.0	52.5	53.0
August 28	53.5	57.0	68.0	76.8	81.5	74.0	59.0	55.0	51.0	50.5	50.5	50.5
August 29	50.0	50.0	52.5	57.5	68.8	57.0	51.0	48.0	45.5	44.0	43.5	42.5
August 30	42.5	43.0	45.5	50.0	50.5	50.0	49.0	47.5	47.0	46.5	47.0	46.0

[a] Correction 20° on all readings (see explanation in footnote, p. 156).

Records from air thermograph in closed galvanized-iron shelter stationed in field of corn at Upper Marlboro, Md., June 15 to September 20, arranged in 10-day periods—1903—Con.

Date.	Hour of reading.											
	6.	8.	10.	Noon.	2.	4.	6.	8.	10.	M.	2.	4.
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
August 31	45.5	47.0	51.0	51.5	53.0	51.0	48.0	46.5	46.0	46.0	46.0	45.0
September 1	45.0	46.0	48.5	59.0	69.0	62.5	54.0	47.5	45.0	43.0	42.0	42.0
September 2	41.5	49.0	61.0	69.0	76.0	65.0	56.0	48.0	45.0	48.0	42.0	42.5
Sum	480.6	533.5	637.0	689.3	742.3	672.5	576.5	525.5	499.3	489.2	486.5	478.2
Corrected sum[a]	680.6	733.5	837.0	889.3	942.3	872.5	776.5	725.5	699.3	689.2	686.5	678.2
Average	68.1	73.4	83.7	88.9	94.2	87.3	77.7	72.6	69.9	68.9	68.7	67.8
September 3	43.0	50.0	70.0	78.0	80.0	70.0	56.0	48.0	45.0	43.0	42.0	41.0
September 4	41.0	55.0	73.5	80.0	81.6	76.0	57.5	49.5	48.0	44.0	42.5	41.0
September 5	42.0	58.0	72.0	78.0	84.0	71.0	62.0	52.0	47.5	44.5	43.5	44.0
September 6	43.5	46.0	60.0	69.0	71.5	63.0	45.0	37.0	32.0	30.0	27.5	26.5
September 7	25.5	39.0	62.0	70.0	76.0	71.0	52.0	40.0	40.0	40.0	42.0	43.0
September 8	43.2	46.0	47.5	46.0	48.2	51.0	47.0	46.0	45.0	45.0	45.5	45.5
September 9	45.5	46.5	58.5	55.0	55.0	58.5	55.0	51.5	49.0	48.5	48.0	46.0
September 10	47.0	51.0	65.0	75.0	80.0	80.0	63.0	57.0	53.5	51.5	48.0	47.5
September 11	47.0	55.0	74.0	80.0	79.0	77.5	65.5	55.0	50.0	49.0	48.5	51.0
September 12	49.0	55.0	65.5	75.0	74.0	61.0	61.0	53.5	51.0	49.0	47.0	45.5
Sum	426.7	501.5	648.0	706.0	729.3	659.0	564.0	489.5	461.0	444.5	434.5	431.0
Corrected sum[a]	626.7	701.5	848.0	906.0	929.3	859.0	764.0	689.5	661.0	644.5	634.5	631.0
Average	62.7	70.2	84.8	90.6	92.9	85.9	76.4	68.95	66.1	64.5	63.5	63.1
September 13	44.0	50.0	71.0	81.0	83.0	84.0	66.0	53.5	49.0	46.5	45.0	48.0
September 14	45.0	49.0	77.0	81.0	82.0	77.0	57.5	50.0	50.0	50.0	48.5	46.0
September 15	47.0	56.0	74.5	80.0	80.0	75.5	57.0	50.5	47.0	47.0	50.0	51.0
September 16	51.0	55.0	73.5	82.0	86.5	76.0	59.0	56.0	55.0	56.0	56.5	56.5
September 17	57.5	55.5	61.0	73.0	72.0	54.5	50.0	47.0	44.0	42.0	38.5	33.0
September 18	29.0	38.0	53.5	60.0	56.0	55.0	38.0	30.0	26.5	24.0	22.5	21.5
September 19	21.7	39.0	54.0	57.0	58.0	53.0	40.0	31.0	27.5	25.0	23.5	22.5
September 20	22.5	38.0	54.0	61.0	61.5	59.0	43.0	32.5	28.0	25.0	22.0	20.5
Sum	317.7	380.5	518.5	575.0	579.0	534.0	410.5	350.5	327.0	315.5	306.5	299.0
Corrected sum[a]	477.7	540.5	678.5	735.0	739.0	694.0	570.5	510.5	487.0	475.5	466.5	459.0
Average	59.7	67.6	84.8	91.9	92.4	86.6	71.3	63.8	60.9	59.4	58.3	57.37

[a] Correction 20° on all readings (see explanation in footnote on p. 156).

Records from air thermograph in closed galvanized-iron shelter stationed in field of corn at Lancaster, Pa., June 8 to September 20, arranged in 10-day periods—1903.

Date.	Hour of reading.											
	6.	8.	10.	Noon	2.	4.	6.	8.	10.	M.	2.	4.
	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.
June 8	......	57.3	63.0	74.8	74.0	70.0	66.5	56.0	51.7	51.0	49.0	46.0
June 9	46.0	60.0	70.5	78.5	81.4	80.0	71.0	60.5	57.2	56.3	55.0	52.6
June 10	52.5	56.5	67.0	65.0	73.8	70.0	57.8	53.5	50.5	48.3	49.0	49.5
June 11	50.5	54.0	58.0	60.5	50.0	53.2	50.0	48.0	45.0	43.8	42.5	42.0
June 12	42.0	44.5	53.3	54.2	53.0	55.2	52.5	42.0	38.2	38.3	36.2	37.0
June 13	37.5	42.0	49.0	53.0	52.0	50.0	47.5	42.3	40.0	39.0	38.5	38.0
June 14	38.5	40.0	41.0	58.3	50.0	51.0	47.3	43.0	40.0	39.5	39.8	39.8
Sum	267.0	354.3	401.8	444.3	434.2	429.4	392.6	345.3	322.6	316.2	310.0	304.9
Corrected sum[a]	357.0	459.0	506.8	509.3	539.2	534.4	497.6	450.3	427.6	421.2	415.0	409.9
Average	59.5	65.6	72.4	72.8	77.0	76.3	71.1	64.3	61.1	60.2	59.3	58.6
June 15	40.5	43.0	51.7	55.0	59.0	60.0	56.5	50.0	47.8	45.0	42.5	44.0
June 16	44.5	61.0	63.0	72.5	68.0	57.5	58.5	51.0	49.0	45.7	45.0	43.3
June 17	43.3	45.0	48.5	50.0	50.5	50.5	49.5	47.2	45.5	43.6	41.5	39.0
June 18	38.3	54.5	63.8	68.0	72.0	72.5	57.5	51.5	45.5	44.0	45.0	45.0
June 19	45.0	48.0	66.0	66.0	74.0	74.0	63.3	55.0	52.5	50.5	49.0	48.0
June 20	48.0	47.5	49.0	49.5	52.0	53.0	54.0	52.0	51.0	51.0	50.0	50.0
June 21	49.5	56.0	62.0	64.8	67.0	65.0	63.0	49.5	43.3	41.0	38.0	37.0
June 22	38.0	66.0	71.0	77.5	73.0	66.0	56.0	49.5	45.0	43.5	42.5	41.5
June 23	41.5	41.5	44.0	44.0	48.5	47.0	46.0	44.5	44.0	43.3	42.5	42.2
June 24	42.5	44.5	57.0	64.2	68.0	61.5	52.0	47.0	45.5	42.7	42.0	41.8
Sum	431.1	507.0	576.0	611.5	632.0	607.0	556.3	497.2	469.1	450.2	438.0	431.8
Corrected sum[a]	581.1	657.0	726.0	761.5	782.0	757.0	706.3	647.2	619.1	600.2	588.0	581.8
Average	58.1	65.7	72.6	76.2	78.2	75.7	70.6	64.7	61.9	60.0	58.8	58.2
June 25	42.8	44.0	48.0	62.0	61.0	63.0	54.5	49.8	47.0	46.5	47.0	45.3
June 26	46.5	50.0	71.5	75.7	76.0	73.5	59.0	52.0	49.0	48.0	48.0	46.5
June 27	50.0	63.0	70.8	77.2	79.0	78.0	64.0	53.0	49.5	49.5	49.2	49.0

[a] Correction 15° on all readings (see explanation in footnote on p. 156).

Records from air thermograph in closed galvanized-iron shelter stationed in field of corn at Lancaster, Pa., June 8 to September 20, arranged in 10-day periods—1903—Cont'd.

Date.	Hour of reading.											
	6.	8.	10.	Noon	2.	4.	6.	8.	10.	M.	2.	4.
	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*
June 28	49.0	52.0	54.0	57.5	55.0	51.3	50.0	49.0	48.3	48.0	47.8	47.8
June 29	48.5	53.0	59.0	61.0	61.5	63.0	63.0	52.5	48.0	47.6	43.5	41.3
June 30	45.0	59.0	74.0	79.0	85.0	73.5	70.0	58.3	55.0	52.5	51.5	50.0
July 1	52.5	65.0	80.5	87.0	90.5	88.5	80.5	65.0	63.0	61.0	57.0	56.0
July 2	65.0	75.0	85.0	90.0	90.0	87.5	82.0	67.5	62.0	57.5	55.5	54.0
July 3	61.0	80.0	92.0	95.5	95.0	63.0	58.0	56.0	55.0	54.5	54.5	54.5
July 4	60.0	63.5	67.0	72.0	84.0	78.5	68.5	59.5	56.0	54.0	53.0	52.5
Sum	520.3	604.5	701.8	756.9	777.0	709.8	649.5	562.6	532.8	519.1	507.0	496.9
Corrected sum [a]	670.3	754.5	851.8	906.9	927.0	859.8	799.5	712.6	682.8	669.1	657.0	646.9
Average	67.0	75.5	85.2	90.7	92.7	85.98	79.95	71.3	68.3	66.9	65.7	64.7
July 5	63.5	73.0	80.0	83.0	80.0	77.0	64.0	57.5	55.5	55.0	55.0	55.0
July 6	57.0	58.0	77.5	85.5	87.0	84.8	79.5	62.5	58.0	50.0	43.3	41.0
July 7	44.0	65.5	77.5	84.0	84.0	83.5	80.0	59.0	52.2	48.5	47.0	46.3
July 8	47.0	68.0	83.0	92.5	95.0	94.5	83.0	62.5	56.5	53.3	52.0	50.0
July 9	52.8	72.5	87.5	93.0	97.0	98.0	86.0	65.5	59.0	56.0	54.5	52.5
July 10	55.7	78.0	90.0	97.0	101.0	75.0	69.5	61.7	60.0	59.5	57.0	54.5
July 11	62.0	80.0	92.0	100.0	63.0	63.0	61.0	58.0	56.0	54.7	54.3	52.8
July 12	58.0	80.0	82.0	78.0	68.0	63.0	57.0	55.5	54.0	53.0	52.5	52.5
July 13	52.5	53.5	57.5	71.0	67.0	62.0	55.5	50.0	47.5	46.0	44.5	42.5
July 14	48.0	70.0	78.5	82.0	75.0	61.0	51.5	48.0	45.0	40.5	37.5	36.0
Sum	540.5	698.5	805.5	866.0	817.0	761.8	687.0	580.2	543.7	516.5	497.6	483.1
Corrected sum [a]	690.5	848.5	955.5	1016.0	967.0	911.8	837.0	730.2	693.7	666.5	647.6	633.1
Average	69.1	84.9	95.6	101.6	96.7	91.2	83.7	73.0	69.4	66.7	64.8	63.3
July 15	48.0	58.0	68.0	69.0	67.5	65.0	55.0	42.5	41.5	43.0	40.5	37.0
July 16	50.0	67.0	75.5	77.5	71.0	71.5	58.0	48.0	46.0	45.0	43.0	39.0
July 17	50.0	71.0	84.0	89.0	85.5	75.0	59.0	52.0	50.5	51.0	51.5	52.5
July 18	52.5	54.0	53.5	62.0	59.0	58.0	55.0	51.5	52.0	50.3	48.0	48.0
July 19	57.0	73.0	80.5	83.0	82.0	75.5	63.0	54.0	52.0	52.0	51.0	49.0
July 20	61.0	64.0	88.5	91.5	91.5	70.5	65.0	51.5	49.0	46.5	45.0	44.0
July 21	45.5	70.0	80.0	85.0	86.0	78.5	65.5	53.0	49.0	49.0	49.0	50.5
July 22	59.0	78.0	75.0	79.5	85.0	81.0	69.0	55.0	50.0	46.0	44.5	43.0
July 23	52.0	72.0	75.0	81.0	82.0	75.5	66.0	53.0	49.5	47.0	45.5	45.0
July 24	55.0	79.0	90.5	92.0	90.0	78.5	65.5	51.0	44.5	39.5	36.5	35.0
Sum	530.0	686.0	770.5	809.5	799.5	729.0	621.0	521.5	484.0	469.3	454.5	443.0
Corrected sum [a]	680.0	836.0	920.5	959.5	949.5	879.0	771.0	671.5	634.0	619.3	604.5	593.0
Average	68.0	83.6	92.1	95.95	94.95	87.9	77.1	67.2	63.4	61.9	60.5	59.3
July 25	50.0	76.5	91.0	98.0	97.5	85.0	70.0	59.5	56.5	53.5	53.0	51.5
July 26	63.0	82.0	90.0	80.5	73.7	77.0	70.0	61.0	57.0	54.0	48.0	43.5
July 27	55.0	72.0	83.0	85.0	82.0	74.0	60.5	49.0	40.5	36.5	32.5	31.0
July 28	41.0	71.5	83.5	88.0	91.5	80.0	66.5	51.5	47.5	46.0	45.5	45.5
July 29	51.5	64.0	76.0	90.0	91.0	76.0	65.0	59.5	57.0	54.5	54.2	53.5
July 30	57.0	81.0	90.0	91.0	88.0	69.5	65.5	60.2	59.0	56.0	53.0	52.0
July 31	54.0	57.2	63 0	63.5	62.0	58.0	51.0	48.0	47.0	43.5	39.0	36.0
August 1	43.0	68.0	81.0	81.5	75.0	70.5	58.0	48.5	44.0	41.0	38.2	37.0
August 2	43.0	59.0	74.5	79.0	84.0	75.0	61.5	56.0	52.0	48.5	46.0	45.5
August 3	48.0	62.0	82.0	79.0	70.0	66.5	60.5	52.0	52.0	51.3	49.5	49.2
Sum	505.5	693.2	814.0	835.5	814.7	731.5	628.5	545.2	512.5	484.8	458.9	444.7
Corrected sum [a]	655.0	843.2	964.0	985.5	964.7	881.5	778.5	695.2	662.5	634.8	608.9	594.7
Average	65.5	84.3	96.4	98.6	96.5	88.2	77.9	69.5	66.3	63.5	60.9	59.5
August 4	50.0	51.7	51.5	52.0	50.2	50.5	51.0	51.5	51.8	51.0	50.5	50.0
August 5	51.0	54.0	60.0	76.0	77.0	70.0	59.0	53.5	51.5	50.5	49.0	48.5
August 6	48.5	51.0	56.0	60.0	63.0	66.0	57.0	55.0	51.0	49.0	45.5	44.0
August 7	48.0	69.0	70.5	73.0	76.0	66.5	54.0	42.0	40.5	36.0	33.5	32.2
August 8	39.0	62.0	66.5	80.0	71.5	66.5	55.0	50.0	49.5	49.5	49.5	49.5
August 9	50.0	56.0	64.0	82.0	86.5	76.5	60.5	54.0	52.0	51.6	48.5	45.7
August 10	48.0	65.0	84.0	88.0	89.3	79.0	65.5	59.0	57.3	56.3	56.0	55.0
August 11	55.0	60.5	62.3	67.5	82.0	61.0	59.0	52.0	48.8	50.0	47.2	42.5
August 12	45.0	60.0	75.0	77.5	80.0	67.8	56.0	45.3	42.5	40.3	38.0	37.0
August 13	40.3	61.0	76.0	72.0	73.2	65.0	56.5	52.8	51.2	50.0	49.5	49.0
Sum	474.8	590.2	665.8	728.0	748.7	668.8	574.5	515.1	496.1	484.2	467.2	453.4
Corrected sum [a]	624.8	740.2	815.8	878.0	898.7	818.8	724.5	665.1	646.1	639.2	617.2	603.4
Average	62.5	74.0	81.6	87.8	89.9	81.9	72.5	66.5	64.6	63.9	61.7	60.3
August 14	48.0	49.0	56.0	58.0	60.5	61.7	50.6	46.5	44.8	42.5	43.0	44.0
August 15	45.5	51.5	68.0	80.7	81.3	70.3	55.5	50.5	49.0	47.7	48.5	46.0
August 16	46.0	50.7	60.0	62.0	61.0	56.5	52.0	49.5	48.0	46.0	44.0	40.0
August 17	45.5	58.0	77.5	81.0	85.5	76.0	60.0	49.2	47.0	44.7	43.0	41.3
August 18	40.5	60.0	81.0	82.4	74.5	71.3	61.0	51.3	47.5	47.5	48.0	49.5
August 19	51.0	58.5	69.0	76.5	72.2	69.0	57.0	54.5	53.5	53.8	54.0	52.3

[a] Correction 15° on all readings (see explanation in footnote, p. 156).

Records from air thermograph in closed galvanized-iron shelter stationed in field of corn at Lancaster, Pa., June 8 to September 20, arranged in 10-day periods—1903—Cont'd.

Date.	Hour of reading.											
	6.	8.	10.	Noon	2.	4.	6.	8.	10.	M.	2.	4.
	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*
August 20	54.0	59.0	68.0	75.8	74.5	70.0	59.5	50.0	46.0	42.0	40.0	38.0
August 21	41.5	63.0	77.2	81.0	80.0	70.7	55.0	47.0	43.7	40.5	39.2	38.8
August 22	42.5	67.0	82.2	83.0	84.5	78.0	65.5	57.5	55.0	53.0	52.0	50.2
August 23	53.5	65.0	79.0	86.3	86.3	78.5	65.5	57.8	57.0	56.0	54.5	54.2
Sum	468.0	581.7	717.9	766.7	760.3	702.0	581.6	513.8	491.5	473.7	466.2	454.3
Corrected sum[a]	618.0	731.7	867.9	916.7	910.3	852.0	731.6	663.8	641.5	623.7	616.2	604.3
Average	61.8	73.2	86.8	91.7	91.0	85.2	73.2	66.4	64.2	62.4	61.6	60.4
August 24	55.0	62.0	73.0	80.5	87.5	82.0	68.8	61.0	57.2	55.0	56.3	56.0
August 25	55.7	65.0	86.3	88.0	87.5	78.0	68.8	61.5	57.0	55.2	54.8	53.7
August 26	55.5	66.5	83.5	85.0	89.0	78.0	65.0	58.0	55.0	53.5	51.5	49.2
August 27	51.0	60.0	65.0	74.5	71.0	64.0	57.0	55.0	54.3	53.0	52.5	51.6
August 28	51.0	51.5	53.0	53.7	53.7	53.0	52.0	50.0	49.5	49.5	49.0	46.7
August 29	47.0	49.5	50.5	51.2	50.5	48.5	47.0	46.0	45.0	44.0	43.0	42.5
August 30	42.7	45.0	48.5	49.0	52.0	49.5	48.2	47.8	47.3	47.0	46.8	46.0
August 31	46.0	47.0	49.0	53.3	56.0	55.0	51.5	49.5	46.0	42.6	44.2	45.0
September 1	45.5	51.0	57.0	68.0	70.0	66.0	54.0	48.0	46.0	44.0	44.5	44.5
September 2	45.3	51.0	73.0	86.5	81.0	74.3	59.0	52.3	49.0	46.5	46.3	47.3
Sum	494.7	548.5	638.8	689.7	698.2	648.3	571.3	529.1	506.3	490.3	488.9	482.5
Corrected sum[a]	644.7	698.5	988.8	839.7	848.2	798.3	721.3	679.1	656.3	640.3	638.9	632.5
Average	64.5	69.9	98.9	83.97	84.8	79.8	72.1	67.9	65.9	64.0	63.9	63.3
September 3	47.6	62.0	83.0	88.0	87.5	75.5	67.5	51.5	48.5	47.3	45.0	43.6
September 4	44.3	60.0	82.0	91.0	85.5	78.0	61.0	55.5	53.0	50.0	49.0	48.0
September 5	50.5	59.0	76.5	89.5	89.0	59.0	55.0	52.3	51.3	48.5	42.0	36.5
September 6	38.0	57.0	68.0	75.7	72.0	60.3	42.5	35.3	33.0	30.5	29.0	27.3
September 7	30.0	46.0	64.8	74.5	76.5	61.0	52.3	48.0	43.5	43.0	43.2	43.8
September 8	42.5	42.5	43.5	44.5	46.0	45.5	45.0	44.0	44.0	44.0	44.0	44.0
September 9	44.0	45.5	50.5	56.0	54.0	54.8	53.0	51.2	51.2	51.2	51.7	51.7
September 10	51.8	57.5	65.7	79.0	82.0	74.3	63.0	58.0	56.5	53.5	50.3	48.0
September 11	48.0	64.0	72.7	87.3	83.0	75.0	61.0	56.0	54.0	51.0	48.3	46.3
September 12	46.0	59.0	80.0	91.8	87.3	79.0	63.5	57.0	52.7	52.7	53.7	53.7
Sum	442.7	552.5	686.7	777.3	762.8	662.4	563.8	508.8	487.7	471.7	456.2	442.9
Corrected sum[a]	592.7	702.5	836.7	927.3	912.8	812.4	713.8	658.8	637.7	621.7	606.2	592.9
Average	59.3	70.3	83.7	92.7	91.3	81.3	71.4	65.9	63.8	62.2	60.6	59.3
September 13	55.0	74.0	86.5	92.0	90.8	79.0	64.5	56.5	54.5	51.5	49.0	47.0
September 14	47.5	68.0	87.0	92.0	87.0	78.0	64.5	57.5	54.3	53.8	52.3	50.0
September 15	52.0	57.5	80.0	90.3	88.0	75.5	60.5	55.5	51.0	49.7	50.3	52.0
September 16	52.0	54.0	61.0	83.0	84.0	76.0	61.0	57.0	57.5	58.3	59.0	59.0
September 17	59.3	59.3	59.3	76.8	62.0	56.0	53.0	49.0	46.3	42.0	37.3	32.7
September 18	31.7	51.5	56.0	65.0	62.3	53.5	37.5	32.3	30.0	28.5	26.7	25.0
September 19	27.0	53.5	66.0	72.0	66.5	56.0	38.5	32.5	29.5	27.3	26.0	24.3
September 20	27.5	54.0	66.0	77.0	70.5	60.7	40.0	33.0	29.5	27.8	25.8	24.0
Sum	352.0	471.8	561.8	648.1	611.1	534.7	419.5	373.3	352.6	338.9	326.4	314.0
Corrected sum[a]	472.0	591.8	881.8	768.1	731.1	654.7	539.5	493.3	472.6	458.9	446.4	334.0
Average	59.0	74.0	85.2	96.0	91.4	81.8	67.4	61.7	59.1	57.4	55.8	41.8

Records from air thermograph in closed galvanized-iron shelter stationed in field of corn at Janesville, Wis., June 1 to September 20, arranged in 10-day periods—1903.

Date.	Hour of reading.											
	6.	8.	10.	Noon	2.	4.	6.	8.	10.	M.	2.	4.
	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*
June 1	......	36.5	39.0	42.0	43.0	42.5	40.0	40.2	40.0	41.0	40.0	38.0
June 2	38.0	41.0	41.5	42.0	48.0	52.0	51.8	42.5	38.0	34.5	34.8	34.0
June 3	38.5	50.0	59.0	60.5	62.0	61.0	56.0	46.0	41.5	40.0	35.0	38.0
June 4	43.0	53.0	57.0	70.0	64.0	59.0	56.0	47.5	46.0	45.0	42.0	41.0
Sum	119.5	180.5	196.5	214.5	217.0	214.5	203.8	176.2	165.5	160.5	151.8	151.0
Corrected sum[a]	164.5	240.5	256.5	274.5	277.0	270.5	263.8	236.2	225.5	220.5	211.8	210.0
Average	54.83	60.12	64.12	68.62	69.25	67.62	65.95	59.05	56.38	55.13	52.95	52.5
June 5	43.0	49.0	55.0	51.8	51.8	53.5	50.0	43.0	37.5	36.5	35.0	37.5
June 6	45.0	59.0	63.0	69.0	71.0	65.5	61.5	49.5	43.0	39.0	35.0	34.0
June 7	42.5	70.0	81.0	84.0	81.0	73.0	68.0	52.0	47.0	44.0	42.0	41.0
June 8	54.0	70.0	78.2	85.0	85.5	87.0	77.0	53.5	50.5	47.0	43.5	38.5

[a] Correction 15° on all readings (see explanation in footnote, p. 156).

Records from air thermograph in closed galvanized-iron shelter stationed in field of corn at Janesville, Wis., June 1 to September 20, arranged in 10-day periods—1903—Cont'd.

Date.	Hour of reading.											
	6.	8.	10.	Noon	2.	4.	6.	8.	10.	M.	2.	4.
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
June 9	45.0	56.0	64.0	70.0	71.0	69.0	60.0	48.5	42.5	41.5	38.5	35.5
June 10	43.5	48.0	51.5	51.0	43.5	43.0	42.8	35.0	30.5	27.8	26.0	29.0
June 11	32.0	38.2	38.0	45.0	48.5	41.5	40.0	36.0	33.7	27.5	25.5	22.5
June 12	34.0	49.0	55.5	60.0	63.0	64.0	56.0	41.0	33.0	28.5	27.0	28.0
June 13	44.0	57.0	66.0	72.5	72.0	75.0	70.0	53.5	50.0	48.0	42.0	41.0
June 14	54.0	68.0	77.5	83.5	83.0	86.5	79.0	60.0	51.5	49.0	45.0	42.0
Sum	437.0	564.2	629.7	671.8	670.3	657.5	604.3	472.0	419.2	388.8	359.5	349.0
Corrected sum [a]	587.0	710.2	770.7	821.8	820.3	807.5	754.3	622.0	569.0	538.8	509.0	490.0
Average	58.7	71.02	77.07	82.18	82.03	80.75	75.43	62.2	56.9	53.88	50.9	49.0
June 15	55.0	77.0	90.0	95.5	99.0	95.5	84.0	63.0	57.0	56.0	51.8	52.5
June 16	60.0	61.0	60.0	66.5	74.0	74.0	68.0	52.0	42.5	37.5	36.0	33.2
June 17	42.0	63.5	78.0	83.5	85.0	83.0	74.0	57.0	50.0	44.0	43.0	43.0
June 18	49.0	64.5	80.0	85.5	89.0	87.0	75.0	63.0	58.0	56.0	50.0	49.5
June 19	52.0	65.5	67.0	64.0	59.0	55.0	53.0	49.0	48.0	45.5	45.0	45.0
June 20	53.0	62.0	69.0	74.0	81.0	70.0	64.0	48.0	42.0	40.0	41.0	42.0
June 21	59.0	73.0	78.0	73.0	72.5	69.0	59.0	52.5	50.0	48.8	48.5	45.5
June 22	48.0	49.0	50.0	55.0	63.0	55.0	50.0	40.0	32.5	28.0	27.5	26.0
June 23	33.5	50.0	58.0	59.0	63.0	57.5	60.0	45.0	35.0	31.0	30.0	29.0
June 24	35.0	55.0	64.5	73.5	73.0	63.0	51.0	49.0	40.0	36.0	32.5	30.0
Sum	486.5	620.5	694.5	729.5	758.5	709.0	638.0	518.5	455.0	422.8	405.3	395.7
Corrected sum [a]	636.5	670.5	844.5	879.5	908.5	859.0	788.0	668.5	605.0	572.8	555.3	545.7
Average	63.65	67.05	84.45	87.95	90.85	85.9	78.8	66.85	60.5	57.28	55.53	54.57
June 25	40.0	61.0	76.5	78.0	77.0	72.5	64.5	51.5	41.0	37.0	34.5	30.2
June 26	43.0	64.0	72.5	74.0	80.0	77.5	68.5	51.0	40.5	37.0	36.0	34.5
June 27	48.0	74.0	85.0	88.0	84.0	73.0	69.5	54.5	45.5	38.0	36.0	36.0
June 28	45.0	65.0	80.0	78.0	82.0	82.5	70.0	60.0	53.0	51.0	48.5	45.0
June 29	54.0	74.0	84.0	88.0	87.0	86.0	76.0	63.5	57.0	57.5	58.2	59.0
June 30	57.5	54.5	61.0	73.0	80.0	66.0	63.0	60.5	58.5	59.8	60.0	61.0
July 1	63.5	70.0	80.5	83.5	80.0	89.0	87.0	62.5	53.5	50.0	50.0	55.0
July 2	55.0	70.0	81.5	88.5	87.0	72.0	78.0	67.5	63.0	60.0	57.5	56.0
July 3	59.0	70.0	79.0	81.0	77.0	80.5	74.0	64.5	62.0	57.0	57.0	57.5
July 4	59.0	70.5	76.8	80.0	67.0	74.5	60.0	51.8	48.0	45.0	42.0	40.0
Sum	524.0	673.0	776.8	812.0	801.0	773.5	710.5	587.3	522.0	492.3	479.7	474.2
Corrected sum [b]	691.3	840.3	944.1	979.3	968.3	940.8	877.8	754.6	689.3	659.6	647.0	641.5
Average	69.13	84.03	94.41	97.93	96.83	94.08	87.78	75.46	68.93	65.96	64.7	64.15
July 5	52.0	71.0	77.6	82.0	83.5	85.0	78.5	58.0	49.5	45.0	42.0	39.5
July 6	55.0	71.0	79.0	80.0	80.0	78.0	75.0	55.5	50.5	48.5	44.0	43.0
July 7	60.0	71.5	79.0	83.0	85.0	88.0	76.5	59.5	55.0	53.0	51.5	51.2
July 8	60.0	73.0	86.0	90.0	90.0	93.0	71.5	62.5	58.0	56.5	56.0	54.0
July 9	53.0	59.0	80.0	91.0	89.0	68.0	54.0	53.8	53.8	54.0	52.5	52.5
July 10	60.0	76.0	75.0	74.0	76.0	68.0	56.0	55.0	53.0	51.5	53.0	53.0
July 11	59.0	75.0	81.5	81.5	83.5	80.0	67.0	54.0	50.0	50.5	49.0	48.0
July 12	60.0	66.0	70.0	70.0	74.0	70.5	56.0	42.0	38.0	35.0	35.5	33.5
July 13	56.0	63.0	70.0	70.0	72.5	72.5	66.0	49.5	39.0	37.0	35.0	33.5
July 14	37.0	60.0	71.0	76.0	78.0	78.0	71.5	50.0	41.5	35.5	32.5	30.5
Sum	552.0	685.5	770.1	797.5	811.5	781.0	672.0	539.8	488.3	466.5	451.0	440.7
Corrected sum [b]	719.3	852.8	937.4	964.8	978.8	948.3	839.3	707.1	655.6	633.8	618.3	508.0
Average	71.93	85.28	93.74	96.48	97.88	94.83	83.93	70.71	65.56	63.38	61.83	50.8
July 15	34.0	54.0	63.0	73.0	85.5	83.0	66.5	50.0	42.5	40.0	40.0	39.2
July 16	40.0	62.0	78.0	85.0	89.0	89.5	75.0	54.5	45.0	39.0	37.0	37.5
July 17	46.0	57.7	56.0	50.0	50.5	52.0	52.3	47.5	46.5	45.0	45.0	45.0
July 18	50.0	67.0	69.5	80.0	84.0	73.0	69.0	48.0	42.5	41.0	39.0	40.0
July 19	49.0	66.0	71.0	74.5	75.0	62.0	60.0	50.0	42.5	39.0	36.5	37.0
July 20	44.0	64.0	73.5	78.5	87.0	85.0	66.0	48.0	43.0	39.5	39.0	39.0
July 21	44.5	62.8	74.0	79.0	77.5	79.0	64.0	45.0	40.5	39.5	36.5	35.5
July 22	43.5	63.0	74.8	78.0	81.0	80.0	60.5	45.0	40.0	35.0	32.5	32.5
July 23	43.0	68.5	82.5	81.0	84.0	84.0	67.5	46.5	40.0	37.5	34.5	32.0
July 24	50.0	76.0	85.0	88.5	93.5	92.0	69.0	50.0	45.5	42.0	40.5	40.0
Sum	444.0	641.0	727.3	767.5	807.0	779.5	649.8	484.5	428.0	397.0	380.5	377.7
Corrected sum [b]	611.3	808.3	894.6	934.8	974.3	946.8	817.1	651.8	595.3	564.3	547.8	545.0
Average	61.13	80.83	89.46	93.48	97.43	94.68	81.71	65.18	59.53	56.43	54.78	54.5
July 25	54.5	78.0	83.5	85.0	89.0	86.5	68.0	55.0	50.0	54.5	51.0	50.0
July 26	52.0	54.0	55.5	56.0	62.5	58.0	52.5	47.5	44.0	41.0	39.0	39.0
July 27	42.5	51.0	67.5	63.5	80.2	78.5	68.0	57.5	51.0	48.5	48.0	49.5
July 28	55.0	76.0	85.5	88.5	90.0	74.5	64.0	57.5	55.0	53.0	52.0	50.0
July 29	51.5	72.0	74.5	71.0	64.0	76.0	69.5	53.5	49.0	46.0	42.0	37.0
July 30	40.5	62.0	66.5	71.0	76.0	72.0	55.5	40.0	35.0	33.5	32.5	30.0
July 31	40.0	68.0	74.0	77.0	82.0	67.5	51.5	40.0	36.0	34.5	37.5	39.0
August 1	46.0	60.0	61.0	65.5	71.5	66.5	54.0	51.0	50.0	45.2	45.0	45.0

[a] Correction 15° on all readings.

[b] Correction 16.73° on all readings.

Records from air thermograph in closed galvanized-iron shelter stationed in field of corn at Janesville, Wis.. June 1 to September 20, arranged in 10-day periods—1903—Cont'd.

Date.	Hour of reading											
	6.	8.	10.	Noon	2.	4.	6.	8.	10.	M.	2.	4.
	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.
August 2	47.5	55.0	78.0	80.0	83.5	81.0	86.5	57.5	54.0	52.0	48.8	49.2
August 3	55.0	58.0	64.5	68.0	66.0	56.5	54.5	52.0	52.0	50.5	51.0	50.0
Sum	484.5	634.0	710.5	725.5	764.7	717.0	624.0	511.5	476.0	458.7	446.8	438.7
Corrected sum *a*	651.8	801.3	877.8	892.8	932.0	884.3	791.3	678.8	643.3	626.0	614.1	606.0
Average	65.18	80.13	87.78	89.28	93.2	88.43	79.13	67.88	64.33	62.6	61.41	60.6
August 4	51.5	56.8	67.0	72.0	73.5	71.5	61.0	54.0	51.0	50.0	50.0	50.0
August 5	48.5	48.0	50.0	67.0	69.0	65.0	60.0	53.5	54.0	50.0	45.0	42.5
August 6	45.0	60.0	69.0	72.0	73.5	71.0	54.0	43.0	38.0	37.0	32.8	30.0
August 7	40.0	65.0	74.5	75.0	73.0	64.0	52.0	46.0	43.5	40.0	41.0	41.8
August 8	48.0	61.0	65.0	76.0	72.5	67.5	55.0	44.5	41.0	39.0	38.5	39.0
August 9	42.0	62.0	74.5	78.0	77.0	69.0	52.5	45.0	41.0	40.5	42.0	41.0
August 10	45.0	65.0	72.5	73.0	69.0	61.0	46.0	37.0	32.5	30.0	30.0	29.0
August 11	35.0	52.0	66.0	60.0	56.0	56.5	46.0	37.0	33.0	30.0	27.0	27.0
August 12	32.5	55.0	62.0	66.0	64.0	52.0	43.0	38.5	36.0	34.0	35.0	35.5
August 13	37.5	49.0	62.0	64.0	68.0	58.5	49.0	40.0	36.0	38.0	37.8	37.0
Sum	425.0	573.8	662.5	703.0	695.5	636.0	518.5	438.5	406.0	388.5	379.1	372.8
Corrected sum *a*	592.3	741.1	829.8	870.3	862.8	803.3	685.8	605.8	573.3	555.8	546.4	540.1
Average	59.23	74.11	82.98	87.03	86.28	80.33	68.58	60.58	57.33	55.58	54.64	54.01
August 14	42.0	60.0	68.0	67.0	61.5	56.0	50.5	47.0	47.0	42.0	41.0	40.0
August 15	38.5	42.0	61.0	57.0	58.0	52.0	46.0	43.5	42.5	41.0	40.0	38.0
August 16	40.0	51.0	64.8	66.5	69.5	63.5	50.0	40.0	35.5	33.0	31.5	30.0
August 17	36.0	63.0	80.0	82.0	82.5	73.5	61.0	50.0	45.5	43.5	43.2	42.0
August 18	44.0	62.0	78.0	80.0	80.0	72.5	61.5	55.0	53.0	51.5	50.5	49.5
August 19	49.5	61.5	81.0	70.5	74.0	67.5	56.0	45.0	41.5	38.5	37.0	36.0
August 20	38.5	58.0	79.0	76.0	78.0	71.0	60.0	48.5	46.0	45.0	43.0	42.0
August 21	45.0	57.0	70.0	75.0	77.0	69.0	64.0	57.0	53.5	53.0	51.0	50.5
August 22	53.0	54.0	65.5	78.0	70.0	68.2	60.0	56.5	56.0	53.5	52.5	52.0
August 23	53.0	61.0	81.5	84.0	79.0	69.0	60.0	53.5	51.5	51.0	51.0	51.0
Sum	439.5	569.5	728.8	736.0	729.5	662.2	569.0	496.0	472.0	452.0	440.7	431.0
Corrected sum *a*	606.8	736.8	896.1	903.3	896.8	829.3	736.3	663.3	639.3	619.3	608.0	598.3
Average	60.68	73.68	89.61	90.33	89.68	82.93	73.63	66.33	63.93	61.93	60.80	59.83
August 24	51.8	66.5	67.5	79.0	73.0	72.0	63.5	62.5	60.5	58.5	56.0	51.0
August 25	52.0	68.0	68.5	69.0	69.5	65.0	56.0	49.0	46.0	43.5	42.0	40.0
August 26	44.8	51.0	56.5	61.0	51.5	46.5	43.5	42.0	43.0	45.0	45.0	46.0
August 27	47.0	50.0	54.0	67.0	52.5	48.5	47.0	45.0	45.0	45.0	45.0	45.0
August 28	46.5	49.0	54.0	61.0	63.0	55.5	49.0	47.5	47.0	47.0	45.5	45.0
August 29	47.5	48.0	49.0	48.0	45.0	44.0	41.0	40.0	40.0	39.5	39.0	39.0
August 30	40.0	41.5	49.0	48.0	47.0	44.3	41.5	41.0	41.0	39.5	40.0	37.0
August 31	42.5	55.0	63.0	63.5	64.0	56.0	45.5	38.5	35.0	34.0	31.5	30.0
September 1	34.0	52.0	72.5	72.0	74.5	62.0	51.5	45.5	41.0	39.0	39.0	39.0
September 2	40.0	44.0	61.0	67.5	73.0	64.0	55.0	51.5	50.5	48.0	45.0	44.0
Sum	446.1	525.0	595.0	636.0	613.0	557.8	493.5	462.5	449.0	439.0	428.0	416.0
Corrected sum *a*	613.4	692.3	762.3	803.3	780.3	725.1	660.8	629.8	616.3	606.3	595.3	583.3
Average	61.34	69.23	76.23	80.33	78.03	72.51	66.08	62.98	61.63	60.63	59.53	58.33
September 3	45.0	55.0	72.0	73.0	74.5	66.0	55.0	47.0	45.0	44.5	41.2	41.2
September 4	43.5	42.0	45.0	58.5	59.0	55.0	45.0	39.0	36.0	34.0	35.0	35.0
September 5	37.5	54.0	68.0	65.0	65.0	52.0	40.0	35.0	31.5	29.0	26.5	25.0
September 6	32.5	39.0	45.0	47.0	49.0	46.5	41.5	40.0	40.0	39.0	39.0	39.5
September 7	42.0	60.0	75.0	74.5	77.0	72.0	64.0	56.0	59.0	59.5	53.5	52.0
September 8	51.5	60.0	68.0	78.0	78.0	71.5	64.0	58.5	56.0	53.5	52.5	51.5
September 9	52.5	55.5	50.0	55.5	54.0	52.5	50.0	46.5	46.6	46.0	42.5	41.0
September 10	41.0	43.0	68.0	72.0	75.0	67.0	52.5	44.5	42.5	40.5	38.0	35.5
September 11	34.5	52.5	67.0	67.0	70.0	62.5	57.5	53.5	53.0	54.5	54.0	54.8
September 12	55.0	65.0	73.0	72.5	73.0	69.0	63.5	61.0	60.0	50.0	48.0	45.0
Sum	435.0	526.0	631.0	663.0	674.5	614.0	533.0	481.0	469.6	450.5	430.2	420.5
Corrected sum *a*	602.3	693.3	698.3	830.3	841.8	681.3	700.3	648.3	636.9	617.8	597.5	587.8
Average	60.23	69.33	69.83	83.03	84.18	68.13	70.03	64.83	63.69	61.78	59.75	58.78
September 13	42.0	47.5	66.0	71.0	71.0	61.0	56.0	53.5	52.5	53.5	54.0	55.0
September 14	54.5	55.0	58.5	69.0	74.0	65.5	52.5	49.5	48.5	49.5	51.5	52.0
September 15	52.5	54.5	60.0	65.0	62.5	59.0	56.5	50.0	46.5	42.5	39.0	37.0
September 16	36.2	37.0	39.0	42.0	41.0	38.0	36.0	35.0	34.0	32.0	31.0	28.0
September 17	26.0	34.5	43.0	47.0	46.0	45.0	34.5	27.5	24.5	21.5	20.5	19.5
September 18	20.0	35.0	55.0	54.0	60.0	50.5	41.0	36.0	34.0	33.8	32.0	31.5
September 19	34.0	48.0	61.0	62.5	69.0	63.0	52.5	48.0	47.5	44.0	41.5	40.0
September 20	38.5	49.0	66.0	68.0	71.0	66.0	55.0	48.0	44.5	42.0	41.0	38.0
Sum	303.7	360.5	448.5	478.5	494.5	448.0	384.0	347.5	332.0	318.8	310.5	301.0
Corrected sum *a*	437.5	494.3	582.3	612.3	628.3	581.8	517.8	481.3	465.8	451.8	444.3	434.8
Average	54.7	61.8	72.8	76.54	78.54	72.73	64.73	60.16	58.23	56.48	55.54	54.35

a Correction 16.73° on all readings (see explanation in footnote, p. 156).

DIFFERENCES IN THE TIME OF MATURING OF CORN IN FOUR STATES AND ON EIGHT TYPES OF SOIL.

As the corn was planted on the eight soil types at the same time and as the same seed was used at all places, and similar treatment was given to the soils and to the crops, the comparative study has made it possible to observe differences in the time of maturing of the corn which might be associated with climatic differences and with those due to differences in the soil types.

The corn at Goldsboro was fully matured on the Norfolk sandy soil the last days of August, and that on the Selma silt loam was cut and shocked on September 4. Instructions were given for sending to the laboratory from the other three stations a set of four ears of corn, two from each soil type, one showing the average most mature and the other the average least mature condition on each of the soil types. These samples were taken on September 14, and the following statements and data show the relative maturity at this time.

The corn received from Upper Marlboro and from Lancaster showed that there is an appreciable difference in the time of maturity of corn between Upper Marlboro and Lancaster. The most advanced corn at Marlboro was on the Norfolk sand; the difference, however, between the most mature corn on the two types of soil was comparatively small. The differences between the least mature on the two soil types was greater, but not very large. The least mature corn on the Sassafras sandy loam was in the water stage, closely approaching the dough stage; while that on the Norfolk sand was about past the water stage, most of the kernels being in the early dough stage. There were greater differences between the corn on the two types of soil at Lancaster than between the two types at Marlboro. Indeed, there were greater differences between the corn on the two types at Lancaster than between the corn grown at Lancaster and at Marlboro, if we compare the most mature in one case with the least mature ears in the other. The differences in the soil types appear to have resulted in greater differences in the time of maturing than were produced by the differences in climate between Upper Marlboro and Lancaster.

On receiving the corn at the central laboratory, the ears were husked, weighed, and dried for moisture determinations. The Janesville corn, reaching the laboratory a day later than the others but picked at the same time, was found to be very appreciably behind that from the other two localities. In the most mature corn the kernels of the Janesville corn were only just barely beginning to dent at the butts of the ears. In the least mature the corn was too green for good boiling ears, while the more advanced ears were a little too mature for roasting.

The percentage of moisture in the ears of corn, as received at the laboratory, and the percentages of water-free shelled corn in the

water-free ears, computed on the basis of the dry weight of the whole ear, were found to be as given in the table which follows:

The green and dry weights of samples of typical ears from the soil types at Lancaster, Upper Marlboro, and Janesville, selected to show the average of the most mature and the average of the least mature ears, together with the percentages of moisture and the percentages of water-free shelled corn, figured on the basis of the water-free dry weight of the cob and the water-free dry weight of the whole ear.

LANCASTER.

	Hagerstown clay loam.				Hagerstown loam.			
	Most mature.		Least mature.		Most mature.		Least mature.	
	Whole ear.	Shelled corn.	Whole ear.	Shelled corn.	Whole ear.	Shelled corn.	Whole ear.	Shelled corn.
Green weight............grams..	368.5	....	422.2	....	380.7	....	404.7	....
Dry weight................do....	190.0	157.5	196.1	165.0	160.3	136.8	113.5	68.3
Per cent of moisture.............	48.44	....	53.55	....	57.89	....	71.95	....
Per cent of shelled corn	82.89	....	84.14	....	85.34	....	60.18	....

UPPER MARLBORO.

	Norfolk sand.				Sassafras sandy loam.			
	Most mature.		Least mature.		Most mature.		Least mature.	
	Whole ear.	Shelled corn.	Whole ear.	Shelled corn.	Whole ear.	Shelled corn.	Whole ear.	Shelled corn.
Green weight............grams..	276.6	....	324.2	....	416.0	....	252.8	....
Dry weight................do....	145.7	127.7	145.8	124.7	237.4	209.6	83.0	63.9
Per cent of moisture.............	47.32	....	55.03	....	42.93	....	67.17	....
Per cent of shelled corn	87.65	....	85.53	....	88.29	....	76.99	....

JANESVILLE.

	Janesville loam.				Miami loam.			
	Most mature.		Least mature.		Most mature.		Least mature.	
	Whole ear.	Shelled corn.	Whole ear.	Shelled corn.	Whole ear.	Shelled corn.	Whole ear.	Shelled corn.
Green weight............grams..	475.0	....	165.5	....	344.5	....	201.0	....
Dry weight................do....	191.1	158.1	26.6	10.1	124.2	102.7	86.1	15.6
Per cent of moisture.............	59.77	....	83.93	....	63.95	....	82.04	....
Per cent of shelled corn	82.73	....	37.97	....	82.69	....	43.21	....

It will be seen from this table that the dryest corn is that of the most mature from the Sassafras sandy loam; standing second is the most mature from the Norfolk sand; third, the most mature from the Hagerstown clay loam; fourth, the least mature corn from the Hagerstown clay loam; fifth, the least mature from the Norfolk sand; sixth, the most mature corn from the Hagerstown loam; seventh, the most mature from the Janesville loam; eighth, the most mature from the Miami loam; ninth, the least mature from the Sassafras sandy loam; tenth, the least mature from the Hagerstown loam; eleventh, the least mature from the Miami loam; and twelfth, the least mature from the Janesville loam.

Comparing the most mature ears only, the Sassafras sandy loam stands first, the Norfolk sand second, the Hagerstown clay loam third, the Hagerstown loam fourth, the Janesville loam fifth, and the Miami loam last.

Making the comparison on the basis of the least mature ears, the Hagerstown clay loam stands first, the Norfolk sand stands second, the Sassafras sandy loam third, the Hagerstown loam fourth, the Miami loam fifth, and the Janesville loam last.

Making the comparison on the basis of the percentage of shelled corn, in the water-free condition, the most mature ears contained 88.29 per cent in the corn from the Sassafras sandy loam; 87.65 per cent in that from the Norfolk sand; 85.34 per cent in that from the Hagerstown loam; 82.89 per cent in that from the Hagerstown clay loam; 82.73 per cent in that from the Janesville loam; and 82.69 per cent in the corn from the Miami loam.

Again making the comparison on the basis of the percentage of shelled corn in the least mature ears, that grown on the Norfolk sand contained 85.53 per cent; that from the Hagerstown loam 85.34 per cent; that from the Hagerstown clay loam 84.14 per cent; that from the Miami loam 43.21 per cent; while that from the Janesville loam gave 37.97 per cent.

SEASONAL VARIATIONS IN THE WATER CONTENTS OF EIGHT SOIL TYPES UNDER THREE CROP CONDITIONS AND FIVE DEGREES OF FERTILIZATION.

In connection with the investigations relating to differences among 8 soil types in the 4 States of North Carolina, Maryland, Pennsylvania, and Wisconsin, one of the series of studies made had for its object the comparison of the seasonal changes in water content of the 8 soil types and under the 5 fertilizations to which they were subjected, the object being primarily to ascertain whether differences in the yield would be in any quantitative way related to differences in the water content of the soils upon which the crops were grown.

It was arranged that soil samples should be taken at the same time in the 4 localities and once per week in the surface foot, once in two weeks in the second foot, and three times during the growing season in the third and fourth feet, these times being (1) at the beginning of the experimental work, (2) near the middle of the growing season, and (3) near the time when the crops upon the ground had approached maturity. The moisture content was determined by drying the entire sample, consisting of a composite of 4 cores extending through the foot sampled, one core each from each of the duplicate subplots representing the type of fertilization and crop.

The amounts of water present in the several soils at the different times of sampling are expressed in two ways, as percentages of the

dry soil, and in absolute measure or inches of depth which the total water in the given foot would represent were it spread out as a continuous sheet over the surface of the field sampled. The results obtained are expressed in the following tables under the respective soil types, fertilizations, and different depths of sampling.

In computing the absolute amounts of moisture in these cases, a specific gravity of 2.65 has been used for the dry soil and the weight of a cubic foot of water has been taken at 62.42 pounds.

Soil moisture in Norfolk sandy soil at Goldsboro, N. C., under corn, with 5 grades of fertilization—1903.

FIRST FOOT.

Period.	Date.	Moisture in soil to which was added per acre—									
		Nothing.		5 tons manure.		10 tons manure.		15 tons manure.		300 pounds guano.	
		Inches.	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*
1	April 29	2.73	18.4	2.91	18.4	3.94	17.6	2.42	15.1	2.27	21.7
3	May 11	2.16	13.0	1.82	12.1	1.88	13.4	1.30	12.5	1.92	13.7
4	May 18	1.69	12.17	1.45	10.34	1.67	11.28	1.38	11.27	1.70	11.61
5	May 27	2.03	12.02	2.09	12.26	1.90	12.35	1.83	12.32	2.65	15.86
6	June 1	2.24	13.0	2.01	12.07	2.36	14.04	2.07	14.81	1.84	13.17
7	June 8	2.75	15.71	2.52	14.16	2.70	15.46	2.61	16.35	2.74	16.50
8	June 15	1.96	12.2	1.84	11.5	1.90	12.2	1.84	12.4	2.04	13.1
9	June 22	1.84	10.74	1.69	10.0	1.78	10.07	1.78	12.60	1.84	11.59
10	June 29	2.30	14.2	2.30	13.9	2.24	13.8	2.19	13.7	2.42	15.9
11	July 6	2.24	13.04	1.84	10.63	1.84	11.11	1.84	11.0	1.90	11.42
12	July 13	1.21	6.97	1.04	5.92	1.09	6.33	.98	5.70	1.09	6.27
13	July 20	1.42	8.14	1.43	8.79	1.67	10.47	1.67	9.97	2.34	15.47
14	July 27	1.38	7.77	1.44	8.68	.81	4.73	.69	4.41	.90	4.97
15	August 3	2.33	13.4	1.96	10.6	2.24	14.1	1.76	11.4	2.01	12.6
16	August 10	1.84	10.58	1.40	8.66	1.50	9.09	1.84	11.15	1.67	9.88
18	August 24	1.86	11.5	1.93	12.3	2.45	15.0	2.01	13.6	1.88	11.20
	Sum	32.98	192.84	29.67	180.31	31.97	191.03	28.11	188.28	31.21	204.94
	Average	2.06	12.05	1.85	11.27	2.00	11.94	1.76	11.77	1.95	12.81

SECOND FOOT.

Period.	Date.	Nothing. Inches.	Per ct.	5 tons manure. Inches.	Per ct.	10 tons manure. Inches.	Per ct.	15 tons manure. Inches.	Per ct.	300 pounds guano. Inches.	Per ct.
1	April 29	3.50	17.3	3.69	19.2	3.76	18.6	4.28	17.1	4.37	23.6
3	May 11	3.30	17.0	2.95	15.3	3.10	16.7	3.20	18.0	3.03	17.5
5	May 27	2.88	14.57	2.65	13.53	2.82	14.54	2.70	15.07	3.05	15.60
7	June 8	3.40	17.50	3.28	17.54	3.07	16.55	3.80	19.46	3.91	21.66
9	June 22	3.22	16.05	2.76	13.99	2.82	15.26	2.82	16.84	2.65	16.67
11	July 6	2.99	15.34	2.86	14.59	2.76	14.26	2.82	17.75	2.42	15.38
13	July 20	2.36	12.50	2.47	12.74	2.70	15.51	2.79	14.63	2.88	15.67
15	August 3	2.76	14.6	2.88	14.9	2.90	16.6	2.24	14.0	2.73	15.30
18	August 24	2.11	16.2	2.37	14.1	3.06	16.6	2.76	17.4	3.40	19.70
	Sum	26.44	141.06	25.51	135.89	26.99	144.62	27.41	150.15	28.04	161.08
	Average	2.83	15.67	2.84	15.10	3.00	16.07	3.05	16.68	3.12	17.90

THIRD FOOT.

Period.	Date.	Nothing. Inches.	Per ct.	5 tons manure. Inches.	Per ct.	10 tons manure. Inches.	Per ct.	15 tons manure. Inches.	Per ct.	300 pounds guano. Inches.	Per ct.
1	April 29	4.04	21.2	3.98	18.6	3.73	16.1	3.14	14.6	5.47	24.9
9	June 22	3.65	18.45	3.51	16.62	3.80	19.58	3.97	19.33	3.40	18.44
18	August 24	4.05	18.1	3.28	18.0	3.38	18.2	4.56	21.2	3.63	19.20
	Sum	11.74	57.75	10.77	53.22	10.91	53.88	11.67	55.13	12.50	62.54
	Average	3.91	19.25	3.59	17.74	3.64	17.96	3.89	18.38	4.17	20.85

FOURTH FOOT.

Period.	Date.	Nothing. Inches.	Per ct.	5 tons manure. Inches.	Per ct.	10 tons manure. Inches.	Per ct.	15 tons manure. Inches.	Per ct.	300 pounds guano. Inches.	Per ct.
1	April 29	5.47	24.0	5.36	21.9	5.12	22.3	5.23	23.0	7.01	26.8
9	June 22	3.80	17.32	3.65	17.29	4.43	21.15	4.32	20.84	3.51	17.38
18	August 24	3.78	17.9	3.64	19.1	4.83	20.5	6.04	26.0	4.28	20.6
	Sum	13.05	59.22	12.65	58.29	14.38	63.95	15.59	69.84	14.80	64.78
	Average	4.35	19.74	4.22	19.43	4.79	21.32	5.20	23.22	4.93	21.59

Soil moisture in Selma silt loam at Goldsboro, N. C., under corn, with 5 grades of fertilization—1903.

FIRST FOOT.

Period.	Date.	Moisture in soil to which was added per acre—									
		Nothing.		5 tons manure.		10 tons manure.		15 tons manure.		300 pounds guano.	
		Inches.	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*
1	April 29	2.15	18.7	2.41	16.8	2.26	15.8	2.21	19.3	2.72	21.8
3	May 11	2.45	17.7	3.21	21.3	2.15	18.2	3.81	18.8	2.53	16.4
4	May 18	2.19	17.27	2.53	16.42	2.65	16.43	2.47	16.35	2.24	14.44
5	May 27	2.90	20.06	3.05	20.00	2.88	20.00	2.70	18.80	2.47	16.79
6	June 1	2.88	21.09	2.94	20.90	3.06	21.28	2.82	18.70	2.70	18.80
7	June 8	3.63	25.92	3.40	24.08	3.28	23.17	3.63	24.61	3.37	21.95
8	June 15	2.53	20.50	2.59	17.70	2.47	17.80	2.70	18.30	2.44	16.10
9	June 22	3.07	19.95	2.82	19.07	1.61	11.43	1.78	12.08	2.11	13.55
10	June 29	3.11	22.00	3.11	20.70	3.34	22.11	3.45	23.80	3.51	23.50
11	July 6	2.65	18.55	2.59	16.36	2.94	20.99	2.59	16.92	2.13	14.28
12	July 13	3.28	22.71	3.17	20.60	2.94	20.81	3.05	21.70	2.88	20.20
13	July 20	2.53	16.73	2.42	15.85	2.30	14.92	2.19	14.39	2.19	14.01
14	July 29	2.19	14.78	2.27	14.24	2.13	13.07	1.73	11.19	2.07	12.77
15	August 3	3.22	20.22	2.53	16.09	2.65	17.10	2.01	12.92	2.36	15.89
16	August 10	2.59	18.29	2.42	15.85	2.47	15.81	2.24	14.23	2.34	14.05
18	August 24	2.28	17.50	2.42	15.70	2.65	17.00	2.19	14.40	2.76	17.90
	Sum	43.65	311.97	43.93	291.76	41.78	282.91	39.57	276.49	40.82	272.53
	Average	2.73	19.50	2.75	18.24	2.61	17.68	2.47	17.28	2.55	17.03

SECOND FOOT.

1	April 29	3.04	21.80	3.60	20.20	3.36	20.20	3.33	19.40	2.45	15.60
3	May 11	3.22	30.50	3.86	24.50	3.79	23.20	3.75	24.10	3.49	22.50
5	May 27	4.32	25.42	4.03	26.32	4.26	25.96	3.78	24.39	3.51	21.25
7	June 8	4.95	31.39	4.22	29.96	4.43	27.61	4.09	30.01	3.95	28.95
9	June 22	4.09	25.50	3.74	26.30	3.74	22.4	3.51	21.4	3.28	20.30
11	July 6	3.91	24.55	4.01	26.77	4.20	26.55	3.74	25.79	4.14	24.0
13	July 20	3.68	23.36	4.32	25.42	4.14	22.09	4.09	24.65	3.45	20.04
15	August 3	4.64	28.28	4.24	25.07	3.36	8.86	3.74	21.45	4.20	23.86
18	August 24	4.26	28.50	3.68	23.50	3.68	26.20	4.03	25.0	4.07	27.0
	Sum	36.11	239.30	35.70	228.04	34.96	203.07	34.06	216.19	32.54	203.50
	Average	4.01	26.59	3.97	25.34	3.88	22.56	3.78	24.02	3.62	22.61

THIRD FOOT.

1	April 29	4.60	31.1	5.93	35.6	4.11	34.0	4.89	30.3	3.66	24.5
9	June 22	4.47	27.6	4.26	26.2	3.57	23.3	3.91	23.2	3.80	23.7
18	August 24	5.87	40.5	4.26	28.0	5.02	29.5	4.32	27.10	4.72	28.5
	Sum	14.94	99.2	14.45	89.8	12.70	86.8	13.12	80.60	12.18	76.7
	Average	4.98	33.07	4.82	29.9	4.23	28.93	4.37	26.87	4.06	25.57

FOURTH FOOT.

1	April 29	5.38	29.20	6.34	32.0	4.35	26.5	4.01	26.1	4.07	29.0
9	June 22	3.59	26.3	5.06	25.6	5.27	28.4	4.20	21.3	4.78	28.1
18	August 24	4.72	28.7	5.29	27.8	5.41	27.2	4.56	23.8	5.06	26.8
	Sum	13.69	84.20	16.69	85.4	15.03	82.1	12.77	71.2	13.91	83.9
	Average	4.56	28.07	5.56	28.47	5.01	27.37	4.26	23.73	4.63	27.97

Soil moisture in Norfolk sandy soil at Goldsboro, N. C., under fallow ground, with 5 grades of fertilization—1903.

FIRST FOOT.

Period.	Date.	Moisture in soil to which was added per acre—									
		Nothing.		5 tons manure.		10 tons manure.		15 tons manure.		300 pounds guano.	
		Inches.	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*
1	April 29	2.28	19.0	2.14	16.87	1.89	15.8	2.26	25.51	2.26	16.79
3	May 11	2.07	13.5	1.95	14.5	1.93	13.4	1.78	12.4	1.98	11.8
4	May 19	1.61	12.0	1.38	11.3	1.76	11.0	1.22	10.5	1.59	10.8
5	May 26	2.13	12.46	1.96	12.55	2.19	13.10	2.13	12.94	2.24	12.27
6	June 1	2.07	12.46	2.19	12.67	2.13	11.65	2.07	12.58	2.07	13.18
7	June 9	2.88	16.11	2.70	16.26	2.65	15.0	2.70	16.21	2.65	16.19
8	June 16	1.98	12.0	1.96	13.1	1.96	12.6	1.84	11.7	2.07	12.60
9	June 25	1.96	11.26	1.78	10.76	1.84	10.88	1.76	10.76	1.67	10.02
10	June 29	2.36	15.10	2.30	13.6	2.47	15.2	2.36	14.10	2.19	13.7
11	July 8	2.30	13.38	2.30	13.47	2.24	13.54	2.30	12.66	2.07	12.0
12	July 14	1.61	9.52	1.67	10.01	1.73	10.49	1.82	10.29	1.73	10.38
13	July 22	1.96	11.57	1.90	11.30	2.07	12.54	1.73	10.01	2.99	18.25
14	July 28	1.99	10.90	1.67	9.18	1.86	10.45	1.73	9.71	1.63	9.32
15	August 4	2.19	12.9	2.24	13.10	2.13	12.8	2.30	13.0	2.09	11.90
16	August 10	1.84	10.74	1.81	10.27	1.99	12.02	1.69	10.19	1.90	11.58
18	August 24	2.34	13.80	2.04	12.60	2.36	13.90	1.71	9.80	1.38	8.40
	Sum	33.57	204.70	31.99	201.54	33.20	204.37	31.40	197.36	32.51	199.18
	Average	2.10	12.80	2.00	12.60	2.08	12.77	1.96	12.34	2.03	12.45

SECOND FOOT.

1	April 29	3.48	22.15	3.48	18.21	3.65	17.78	2.06	11.28	6.94	34.00
3	May 11	3.11	16.0	3.00	15.0	3.22	17.00	3.14	17.3	3.22	17.0
5	May 26	2.70	14.07	2.70	13.95	2.82	15.06	2.70	14.28	2.65	13.61
7	June 9	3.34	18.18	3.34	16.25	3.57	17.56	3.40	16.77	3.51	17.84
9	June 25	2.88	14.49	2.47	13.27	2.76	15.05	2.94	15.22	2.39	14.39
11	July 8	2.70	14.59	2.76	14.46	2.82	15.65	3.17	16.37	2.47	15.14
13	July 22	2.88	15.38	3.41	11.25	2.86	15.15	2.76	14.16	2.94	17.11
15	August 4	2.99	15.20	2.57	12.50	3.25	14.90	3.30	18.20	2.47	14.00
18	August 24	2.84	12.80	3.75	14.80	2.67	14.90	2.81	15.60	2.09	12.70
	Sum	26.92	142.86	27.48	129.69	27.62	143.05	26.28	139.21	28.68	155.79
	Average	2.99	15.87	3.05	14.41	3.07	15.90	2.92	15.47	3.18	17.31

THIRD FOOT.

1	April 29	4.60	23.1	3.96	12.05	4.14	18.51	4.33	20.11	9.61	48.7
9	June 25	3.34	16.81	3.43	16.69	3.86	19.31	3.57	18.34	3.57	17.13
18	August 4	3.45	16.20	3.91	17.0	3.80	18.00	3.43	16.5	4.03	20.40
	Sum	11.39	56.11	11.30	45.74	11.80	55.82	11.33	54.95	17.21	86.23
	Average	3.80	18.70	3.77	15.25	3.70	18.61	3.78	18.32	5.74	28.74

FOURTH FOOT.

1	April 29	4.97	21.05	4.49	19.89	5.87	24.71	4.60	19.41	4.98	21.95
9	June 25	3.74	18.21	3.97	18.90	3.91	19.26	3.80	17.74	3.72	17.89
18	August 24	3.51	16.50	3.86	16.40	3.82	18.20	3.57	16.50	3.11	15.00
	Sum	12.22	55.76	12.32	55.19	13.60	62.17	11.97	53.65	11.81	54.84
	Average	4.07	18.59	4.11	18.40	4.54	20.73	3.99	17.88	3.93	18.28

Soil moisture in Selma silt loam at Goldsboro, N. C., under fallow ground, with 5 grades of fertilization—1903.

FIRST FOOT.

Period.	Date.	Moisture in soil to which was added per acre— Nothing.		5 tons manure.		10 tons manure.		15 tons manure.		300 pounds guano.	
		Inches.	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*
1	April 29	3.28	24.05	3.28	22.44	3.14	23.28	3.05	21.07	2.60	18.15
3	May 11	2.64	16.8	2.68	18.5	2.66	18.1	2.56	16.4	2.62	15.5
4	May 19	2.47	16.7	2.36	14.2	2.42	17.6	2.47	16.2	2.31	15.2
5	May 26	2.53	16.66	2.42	17.79	2.65	18.0	2.76	18.32	2.53	16.92
6	June 1	2.76	19.0	2.91	19.51	2.94	18.55	2.90	20.44	2.67	18.27
7	June 9	3.45	24.59	2.99	24.07	2.26	24.39	2.88	24.04	3.05	22.85
8	June 16	2.36	15.5	2.57	16.8	2.53	16.6	2.36	16.1	2.59	17.50
9	June 23	1.70	11.4	2.07	13.4	1.84	11.9	1.67	10.5	2.56	15.8
10	June 29	3.28	21.0	3.02	19.4	3.11	22.3	2.99	19.2	3.05	19 2
11	July 8	2.65	18.77	2.82	17.50	3.34	21.25	2.82	17.03	2.65	16.43
12	July 14	3.11	20.0	3.40	21.5	3.11	20.2	3.11	20.3	3.11	19 10
13	July 22	2.42	15.1	2.42	14.7	2.34	15.0	2.76	16.80	2.47	15 70
14	July 28	2.47	15.93	2.66	16.0	2.53	16.42	2.76	16.55	2.76	16 90
15	August 4	2.70	17.54	2.65	17.29	3.17	18.86	2.70	16.96	2.94	18 09
16	August 10	2.76	16.96	2.47	14.93	2.99	19.19	2.57	15.49	2.65	15 95
18	August 24	2.53	15.50	2.88	18.50	3.43	21.40	2.99	18.30	2.76	17 0
	Sum	43.11	285.50	43.60	284.53	45.46	303.04	43.30	283.70	43.32	268.56
	Average	2.70	17.84	2.73	17.78	2.84	19.0	2.70	17.73	2.71	16.80

SECOND FOOT.

Period.	Date.	Nothing. Inches.	Per ct.	5 tons manure. Inches.	Per ct.	10 tons manure. Inches.	Per ct.	15 tons manure. Inches.	Per ct.	300 pounds guano. Inches.	Per ct.
1	April 29	3.55	18.59	4.10	29.20	4.09	30.05	4.18	26.8	4.37	26.85
3	May 11	4.14	25.0	4.25	26.0	3.97	24.0	4.33	23.7	3.91	24.50
5	May 26	3.57	20.95	3.40	21.38	3.50	24.20	3.57	22.14	3.41	22.02
7	June 9	4.27	28.96	4.43	27.79	4.55	28.32	4.72	27.52	4.26	28.14
9	June 25	3.05	20.4	2.82	18.4	3.19	19.5	3.63	21.6	3.34	20.50
11	July 8	3.80	23.49	4.03	22.36	4.32	25.95	4.03	26.32	4.41	25.70
13	July 22	4.43	29.7	4.03	24.9	4.11	23.2	3.80	27.0	4.20	26.0
15	August 4	4.11	23.44	4.40	24.57	3.55	23.97	4.11	24.88	3.82	24.34
18	August 24	3.97	24.40	4.03	24.40	3.84	24.0	4.09	25.0	4.43	28.0
	Sum	34.89	214.93	35.49	219.00	35.12	223.19	36.46	224.96	36.15	226.05
	Average	3.88	23.88	3.94	24.33	3.90	24.80	3.63	25.00	4.02	25.12

THIRD FOOT.

Period.	Date.	Nothing. Inches.	Per ct.	5 tons manure. Inches.	Per ct.	10 tons manure. Inches.	Per ct.	15 tons manure. Inches.	Per ct.	300 pounds guano. Inches.	Per ct.
1	April 29	5.94	33.5	6.18	38.41	6.08	31.06	4.70	29.78	4.75	33.30
9	June 25	4.03	24.6	3.82	24.2	3.86	22.3	3.74	23.0	4.05	23.90
18	August 24	5.48	30.50	4.14	25.4	4.28	26.0	4.83	29.10	5.18	30.10
	Sum	15.45	88.60	14.14	88.01	14.22	79.36	13.27	81.88	13.98	87.30
	Average	5.15	29.53	4.71	29.33	4.74	26.45	4.42	27.29	4.66	29.10

FOURTH FOOT.

Period.	Date.	Nothing. Inches.	Per ct.	5 tons manure. Inches.	Per ct.	10 tons manure. Inches.	Per ct.	15 tons manure. Inches.	Per ct.	300 pounds guano. Inches.	Per ct.
1	April 29	5.02	25.98	3.60	28.45	5.69	31.21	5.44	29.81	4.97	26.21
9	June 25	5.10	27.6	4.80	23.6	5.47	29.70	5.47	28.50	4.87	23.30
18	August 24	5.41	29.20	5.99	26.0	6.02	32.0	5.64	30.40	4.60	29.90
	Sum	15.53	82.78	14.39	78.05	17.18	92.91	16.55	88.71	14.44	79.41
	Average	5.18	27.59	4.79	29.35	5.72	30.97	5.52	29.57	4.81	26.47

Soil moisture in Norfolk sandy soil at Goldsboro, N. C., under potatoes, with 5 grades of fertilization—1903.

Period.	Date.	Moisture in soil to which was added per acre—									
		Nothing.		5 tons manure.		10 tons manure.		15 tons manure.		300 pounds guano.	
		Inches.	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*
	FIRST FOOT.										
1	May 1	2.88	20.6	2.82	18.10	2.59	20.4	2.56	16.6	2.35	15.9
3	May 12	2.18	14.5	2.40	13.70	2.01	12.5	1.78	12.7	1.52	11.3
4	May 19	1.67	11.0	1.55	11.70	1.61	10.3	1.50	11.0	1.55	9.50
5	May 26	2.07	13.19	2.30	13.51	2.13	12.60	2.24	12.58	1.78	11.44
6	June 1	2.24	12.19	2.24	14.18	1.90	13.14	2.19	12.37	2.01	11.18
7	June 9	2.53	16.48	2.53	16.06	2.76	16.27	2.53	15.49	2.51	15.12
8	June 16	1.96	12.2	2.07	13.2	1.99	12.60	1.93	11.80	1.78	11.50
9	June 24	1.76	10.61	1.92	11.26	1.84	10.59	1.67	9.07	1.44	8.39
10	June 29	3.17	19.4	2.47	15.40	2.30	14.0	2.36	13.60	2.19	12.50
11	July 8	1.67	9.89	1.78	10.30	1.55	9.12	1.55	9.00	1.27	7.36
12	July 14	1.21	7.29	.92	5.26	.98	5.45	.98	5.70	.98	5.57
13	July 21	1.32	7.67	1.73	9.52	1.38	7.89	1.44	8.62	1.53	8.81
14	July 28	1.81	10.50	1.46	8.35	1.32	8.09	1.09	6.21	1.44	8.04
15	August 4	2.21	13.9	1.96	11.70	2.19	13.5	1.96	12.9	2.27	13.0
16	August 10	1.84	11.31	1.81	11.07	1.82	10.86	1.55	9.25	1.42	7.98
18	August 28	1.57	9.5	1.73	10.80	1.38	8.2	1.38	7.7	1.38	7.9
	Sum	32.09	200.33	31.69	194.13	29.75	185.51	28.71	173.89	27.42	163.49
	Average	2.01	12.52	1.98	12.13	1.85	11.59	1.79	10.87	1.71	10.22
	SECOND FOOT.										
1	May 1	3.57	18.8	3.67	17.7	3.55	16.9	3.63	19.8	2.82	14.90
3	May 12	2.76	14.2	3.26	16.0	3.04	15.5	2.97	14.6	3.03	15.70
5	May 26	2.88	16.13	2.47	13.72	2.59	13.51	2.88	15.11	2.59	13.15
7	June 9	3.22	15.43	3.25	15.47	3.08	16.68	3.28	17.28	3.57	18.13
9	June 26	3.05	15.01	2.61	13.61	2.70	14.19	2.94	14.53	2.70	14.33
11	July 8	2.99	15.07	2.59	13.55	2.65	13.49	2.82	14.80	2.65	14.42
13	July 21	2.88	16.52	2.39	12.86	2.19	11.45	2.59	13.27	2.36	12.13
15	August 4	3.28	15.1	2.67	12.6	2.79	14.2	2.27	12.5	2.50	14.40
18	August 28	2.39	12.7	2.37	12.1	2.30	12.2	2.47	13.3	2.01	11.90
	Sum	27.02	138.96	25.28	127.61	24.89	132.12	25.85	135.19	24.23	129.06
	Average	3.00	15.44	2.81	14.18	2.77	14.68	2.87	15.02	2.59	14.34
	THIRD FOOT.										
1	May 1	4.42	20.8	5.09	21.8	4.70	20.5	4.87	20.5	4.05	19.7
9	June 26	3.22	16.57	2.99	14.68	3.82	18.78	3.63	17.20	3.28	16.43
18	August 18	2.31	15.5	2.99	15.2	3.57	16.0	3.03	15.0	3.22	15.1
	Sum	9.95	52.87	11.07	51.68	12.09	55.28	11.53	52.70	10.55	51.23
	Average	3.32	17.62	3.69	17.23	4.03	18.43	3.84	17.57	3.52	17.08
	FOURTH FOOT.										
1	May 1	5.24	22.30	5.18	22.27	6.13	23.17	5.43	22.11	4.09	19.83
9	June 26	4.03	17.37	3.51	16.30	4.49	20.63	3.74	16.84	3.57	16.45
18	August 28	3.40	15.80	3.74	17.0	4.14	18.9	3.53	15.2	3.63	15.3
	Sum	12.67	55.47	12.43	55.57	14.76	62.70	12.70	54.15	11.29	51.58
	Average	4.22	18.49	4.14	18.52	4.92	20.9	4.23	18.05	3.76	17.19

Soil moisture in Selma silt loam at Goldsboro, N. C., under potatoes, with 5 grades of fertilization—1903.

FIRST FOOT.

Period.	Date.	Moisture in soil to which was added per acre—									
		Nothing.		5 tons manure.		10 tons manure.		15 tons manure.		300 pounds guano.	
		Inches.	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*
1	May 1	2.52	19.48	2.13	18.61	2.50	20.37	2.46	18.32	2.60	20.56
3	May 12	2.47	16.0	2.19	14.8	2.36	16.00	2.39	15.20	2.40	16.90
4	May 19	2.30	15.2	2.19	15.2	2.30	15.5	2.30	16.00	2.21	16.00
5	May 26	2.53	17.39	2.70	17.22	2.53	16.18	2.53	16.41	2.42	15.79
6	June 1	2.82	18.70	2.82	17.56	2.82	19.37	2.88	18.12	2.82	18.22
7	June 9	3.28	20.1	2.99	19.6	3.13	21.5	2.70	19.2	2.88	18.40
8	June 16	2.47	15.9	2.56	16.10	2.42	16.1	2.53	17.3	2.24	14.80
9	June 24	2.59	15.6	2.42	14.8	2.15	13.7	2.36	15.7	2.36	14.4
10	June 29	2.53	16.1	2.59	16.3	2.65	16.9	2.42	16.6	2.36	15.7
11	July 8	2.01	12.96	2.01	12.37	1.84	11.39	2.36	14.64	2.01	12.28
12	July 14	2.76	17.1	2.63	16.6	2.61	16.6	2.47	15.3	2.59	17.0
13	July 21	2.24	14.3	2.19	13.7	1.93	11.7	2.16	13.9	2.04	12.1
14	July 28	1.78	10.54	1.96	11.72	1.86	11.67	1.90	11.66	1.99	12.52
15	August 4	2.76	17.35	2.28	14.07	2.66	16.81	2.57	15.91	2.73	16.89
16	August 10	2.24	13.36	2.13	13.17	2.24	14.89	2.07	13.53	1.96	12.55
18	August 28	2.42	16.10	2.53	16.00	2.65	17.00	2.58	16.10	2.59	16.50
	Sum	39.72	256.18	38.32	257.82	38.65	255.73	38.68	253.89	38.20	250.61
	Average	2.63	16.01	2.40	16.11	2.42	15.98	2.42	15.87	2.40	15.66

SECOND FOOT.

1	May 1	3.68	22.14	3.88	22.32	3.98	24.16	3.72	22.63	3.59	21.57
3	May 12	3.43	24.50	3.80	25.10	3.49	21.20	3.75	24.50	3.98	25.00
5	May 26	3.51	33.93	3.86	22.94	3.57	22.63	3.74	20.97	3.57	21.23
7	June 9	4.03	25.2	4.20	25.90	4.26	24.90	3.91	22.40	3.91	23.10
9	June 26	3.11	21.1	3.51	19.90	2.99	18.70	3.05	19.00	3.17	19.10
11	July 8	3.45	22.99	3.74	23.39	3.57	21.45	3.57	21.16	3.57	20.95
13	July 21	3.78	23.5	3.91	21.90	3.57	21.10	3.74	22.0	3.86	21.2
15	August 4	3.63	21.72	3.57	21.53	3.86	22.41	3.68	21.47	3.34	20.57
18	August 28	3.83	24.10	4.37	27.20	4.83	26.70	4.26	25.50	3.68	22.80
	Sum	32.45	219.18	34.84	210.18	34.12	203.25	33.42	199.63	32.67	195.52
	Average	3.61	24.35	3.87	23.35	3.79	22.58	3.71	22.18	3.63	21.72

THIRD FOOT.

1	May 1	5.16	27.91	3.74	20.48	3.98	21.65	4.66	28.86	4.51	27.53
9	June 26	4.43	28.10	3.51	29.00	4.20	23.2	3.57	22.00	3.51	22.2
18	August 28	4.95	27.70	4.95	28.00	5.06	26.4	5.06	29.20	5.87	33.3
	Sum	14.54	83.71	12.20	77.48	13.24	71.25	13.29	80.06	13.89	83.03
	Average	4.85	27.90	4.07	25.83	4.41	23.75	4.43	26.69	4.63	27.68

FOURTH FOOT.

1	May 1	4.28	29.89	5.24	27.49	4.32	28.24	5.24	22.42	4.58	29.36
9	June 26	4.83	28.10	5.43	25.60	4.89	29.00	5.29	23.90	4.26	22.30
18	August 28	5.41	29.00	6.33	31.80	5.99	33.30	5.52	31.50	5.41	27.20
	Sum	14.52	86.99	17.00	84.89	15.20	90.54	16.05	77.82	14.25	78.86
	Average	4.84	28.99	5.67	28.29	5.07	30.18	5.35	25.94	4.75	26.29

Soil moisture in Norfolk sand at Marlboro, Md., under corn, with 5 grades of fertilization—1903.

FIRST FOOT.

Period.	Date.	Moisture in soil to which was added per acre—									
		Nothing.		5 tons manure.		10 tons manure.		15 tons manure.		300 pounds guano.	
		Inches.	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*
1	May 1	1.96	12.0	3.11	11.9	3.34	13.5	2.19	14.0	2.65	16.3
3	May 12	1.50	9.2	1.50	9.6	1.61	10.2	1.84	10.4	1.50	9.2
4	May 18	1.15	8.4	1.38	8.8	1.50	10.1	1.50	10.3	1.50	9.1
5	May 25	1.61	11.3	1.96	12.3	2.07	12.9	1.96	13.0	1.96	11.5
6	June 1	1.96	12.4	1.96	13.1	1.96	12.5	1.96	12.8	1.96	11.8
7	June 8	2.19	13.6	2.30	14.2	2.30	14.2	2.19	13.3	2.07	12.1
8	June 15	2.65	15.6	2.53	15.7	2.53	16.3	2.65	15.3	2.65	16.1
9	June 23	2.65	15.6	2.76	17.3	2.76	16.3	2.76	17.1	2.30	16.3
10	June 30	2.30	14.5	2.42	14.6	2.42	15.3	2.42	15.3	2.65	15.8
11	July 7	2.07	13.4	2.42	14.9	2.30	13.8	2.30	14.5	2.42	14.0
12	July 14	2.42	14.5	2.30	14.5	2.65	15.6	2.53	14.9	2.53	15.7
13	July 21	2.19	14.2	2.30	14.4	1.96	14.0	2.19	13.0	2.19	14.7
14	July 28	1.50	9.10	1.15	7.5	1.38	8.0	1.27	8.0	1.38	8.0
15	August 4	1.61	9.70	1.61	9.5	1.61	9.8	1.38	8.6	1.38	8.5
16	August 11	1.73	10.4	1.73	10.5	1.50	9.6	1.61	9.8	1.38	8.80
18	August 26	1.50	8.7	1.61	10.2	1.27	7.9	1.27	8.1	1.61	10.0
	Sum	30.99	192.60	33.04	199.00	33.16	202.00	32.02	198.4	32.13	197.9
	Average	1.94	12.04	2.07	12.44	2.07	12.63	2.00	12.4	2.01	12.37

SECOND FOOT.

Period.	Date.	Nothing. Inches.	Nothing. Per ct.	5 tons manure. Inches.	5 tons manure. Per ct.	10 tons manure. Inches.	10 tons manure. Per ct.	15 tons manure. Inches.	15 tons manure. Per ct.	300 pounds guano. Inches.	300 pounds guano. Per ct.
1	May 1	3.22	17.6	2.53	15.1	2.65	17.5	3.34	16.2	3.34	18.8
3	May 12	2.88	15.3	2.65	14.3	2.76	15.0	1.76	15.5	2.99	16.8
5	May 25	2.88	15.6	2.76	15.3	2.42	13.9	2.65	14.3	2.99	16.8
7	June 8	2.65	15.1	2.88	16.6	2.76	15.2	2.88	16.3	2.76	15.2
9	June 23	2.99	16.9	3.68	18.7	3.45	19.9	3.91	21.2	4.14	20.6
11	July 7	2.88	16.3	3.11	16.9	2.65	14.8	3.11	17.9	3.22	17.8
13	July 21	2.88	16.0	2.88	15.7	2.76	14.0	2.65	14.7	3.22	15.9
15	August 4	2.19	12.50	2.42	13.0	2.30	12.50	2.30	12.7	2.42	14.2
18	August 26	1.84	11.20	1.61	9.80	1.73	10.0	2.07	13.5	1.84	10.6
	Sum	24.41	136.50	24.52	135.40	23.48	132.80	24.67	142.3	26.92	146.5
	Average	2.71	15.17	2.73	15.04	2.61	14.76	2.74	15.81	2.99	16.28

THIRD FOOT.

Period.	Date.	Nothing. Inches.	Nothing. Per ct.	5 tons manure. Inches.	5 tons manure. Per ct.	10 tons manure. Inches.	10 tons manure. Per ct.	15 tons manure. Inches.	15 tons manure. Per ct.	300 pounds guano. Inches.	300 pounds guano. Per ct.
1	May 1	2.99	17.1	3.11	16.8	3.57	16.2	3.34	16.2	3.11	15.9
9	June 23	3.57	17.2	2.99	14.6	3.22	17.4	3.68	18.3	3.45	17.5
18	August 26	3.11	16.5	2.30	11.5	2.99	15.3	2.99	15.4	2.42	12.3
	Sum	9.67	50.8	8.40	42.90	9.78	48.9	10.01	49.9	8.98	45.7
	Average	3.22	16.93	2.80	14.30	3.26	16.3	3.34	16.63	2.99	15.23

FOURTH FOOT.

Period.	Date.	Nothing. Inches.	Nothing. Per ct.	5 tons manure. Inches.	5 tons manure. Per ct.	10 tons manure. Inches.	10 tons manure. Per ct.	15 tons manure. Inches.	15 tons manure. Per ct.	300 pounds guano. Inches.	300 pounds guano. Per ct.
1	May 1	2.07	11.8	2.30	12.7	2.42	13.6	2.76	15.7	2.53	14.3
9	June 23	2.88	15.9	3.22	15.9	2.88	16.0	3.22	17.9	2.88	14.9
18	August 26	2.19	11.8	1.96	10.2	2.30	13.0	3.45	19.3	2.42	13.8
	Sum	7.14	39.5	7.48	38.8	7.60	42.6	9.43	52.9	7.83	43.0
	Average	2.38	13.17	2.49	12.93	2.53	14.2	3.14	17.6	2.61	14.33

Soil moisture in Sassafras sandy loam at Marlboro, Md., under corn, with 5 grades of fertilization—1903.

FIRST FOOT.

Period.	Date.	Nothing.		5 tons manure.		10 tons manure.		15 tons manure.		300 pounds guano.	
		Inches.	Per ct.	Inches.	Per ct.	Inches.	Per ct.	Inches.	Per ct.	Inches.	Per ct.
1	May 1	3.11	17.0	2.65	17.4	2.65	17.2	2.30	16.5	2.42	16.8
3	May 12	2.42	14.6	2.42	14.8	2.30	15.1	2.19	14.4	2.19	13.8
4	May 18	2.19	14.4	2.07	14.3	2.30	14.6	2.19	14.3	2.07	13.0
5	May 25	2.30	14.7	2.30	14.7	2.42	16.5	2.07	12.8	1.84	10.9
6	June 1	2.76	17.9	2.53	17.6	2.88	18.4	2.53	18.0	2.65	18.4
7	June 8	2.30	15.6	2.65	17.0	2.42	15.7	2.30	15.6	2.53	16.2
8	June 15	3.11	18.6	2.99	19.3	2.76	18.7	2.88	18.1	2.88	17.9
9	June 23	2.30	17.2	2.19	18.8	2.42	17.9	3.11	18.1	3.22	23.1
10	June 30	3.11	18.2	2.88	18.1	2.99	18.8	2.76	18.0	2.88	17.9
11	July 7	2.53	15.6	2.53	15.7	2.42	15.2	2.42	14.9	2.42	15.1
12	July 14	2.76	18.2	2.76	18.2	2.88	18.4	2.88	18.0	2.99	18.4
13	July 21	2.07	14.0	2.19	15.0	2.19	14.8	2.19	14.7	2.07	14.3
14	July 28	1.73	11.0	1.50	9.80	1.61	10.30	1.50	9.50	1.38	8.9
15	August 4	1.96	12.7	2.99	18.7	1.96	12.60	1.61	11.00	1.96	12.60
16	August 11	2.53	16.0	2.30	14.8	2.30	15.0	2.42	15.5	2.42	15.5
18	August 26	2.07	13.8	1.96	12.5	1.73	11.6	1.84	11.7	1.96	12.4
	Sum	39.25	249.5	38.91	255.7	38.23	250.8	37.19	241.10	37.88	245.20
	Average	2.45	15.59	2.45	15.98	2.39	15.68	2.33	15.07	2.37	15.33

SECOND FOOT.

Period.	Date.	Nothing.		5 tons manure.		10 tons manure.		15 tons manure.		300 pounds guano.	
		Inches.	Per ct.	Inches.	Per ct.	Inches.	Per ct.	Inches.	Per ct.	Inches.	Per ct.
1	May 1	3.22	20.7	3.45	21.1	2.99	18.8	3.22	19.4	2.88	18.9
3	May 12	3.11	19.4	3.11	19.6	3.34	19.2	2.99	18.2	2.88	17.9
5	May 25	2.65	15.5	2.53	14.4	2.53	15.3	2.42	13.5	2.53	15.0
7	June 8	2.99	19.3	2.88	17.2	2.76	17.8	2.88	16.9	2.65	17.3
9	June 23	2.76	18.2	3.34	18.6	3.57	19.6	2.99	20.0	3.11	19.7
11	July 7	2.88	17.5	3.22	18.7	2.99	18.1	2.99	18.3	2.88	18.0
13	July 21	2.88	18.1	2.88	18.8	2.88	19.2	2.99	19.0	2.88	18.5
15	August 4	2.76	16.1	2.76	16.1	2.65	15.5	2.53	16.10	2.88	17.8
18	August 26	2.88	18.10	2.30	14.8	2.76	16.7	2.65	17.0	2.65	16.8
	Sum	26.13	162.90	26.47	159.3	26.47	160.2	25.66	158.40	25.34	159.90
	Average	2.90	18.10	2.94	17.7	2.94	17.8	2.85	17.6	2.82	17.77

THIRD FOOT.

Period.	Date.	Nothing.		5 tons manure.		10 tons manure.		15 tons manure.		300 pounds guano.	
		Inches.	Per ct.	Inches.	Per ct.	Inches.	Per ct.	Inches.	Per ct.	Inches.	Per ct.
1	May 1	4.14	24.3	3.68	23.0	3.68	24.0	3.68	23.0	4.14	22.9
9	June 23	3.68	21.9	3.80	23.4	3.22	17.6	3.80	21.7	3.91	21.1
18	August 26	3.22	18.7	3.34	19.7	3.57	21.20	2.99	17.3	2.99	17.10
	Sum	11.04	64.9	10.82	66.1	10.47	62.80	10.47	62.0	11.04	61.10
	Average	3.68	21.63	3.61	22.03	3.49	20.93	3.49	20.66	3.68	20.37

FOURTH FOOT.

Period.	Date.	Nothing.		5 tons manure.		10 tons manure.		15 tons manure.		300 pounds guano.	
		Inches.	Per ct.	Inches.	Per ct.	Inches.	Per ct.	Inches.	Per ct.	Inches.	Per ct.
1	May 1	4.03	26.1	4.03	22.9	4.26	27.2	5.18	27.1	4.83	26.2
9	June 23	4.37	24.5	4.03	24.5	4.03	24.6	4.26	24.5	4.37	26.0
18	August 26	3.68	21.50	3.51	20.0	3.34	18.10	3.22	19.0	3.97	23.50
	Sum	12.08	72.10	11.57	77.4	11.63	69.90	12.66	70.6	13.17	75.70
	Average	4.03	24.03	3.86	25.8	3.88	23.30	4.22	23.53	4.39	25.23

Soil moisture in Norfolk sand at Marlboro, Md., under fallow, with 5 grades of fertilization—1903.

FIRST FOOT.

Period.	Date.	Moisture in soil to which was added per acre—									
		Nothing.		5 tons manure.		10 tons manure.		15 tons manure.		300 pounds guano.	
		Inches.	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*
1	May 1	1.96	11.8	2.19	13.1	2.30	14.7	2.19	13.8	1.84	11.2
3	May 12	1.61	10.2	1.61	10.1	1.73	10.6	1.73	10.9	1.38	9.1
4	May 18	1.38	9.2	1.61	10.0	1.50	10.1	1.50	9.9	1.38	8.6
5	May 26	1.96	12.8	1.96	11.8	1.96	12.7	1.73	12.4	1.73	11.4
6	June 1	2.07	12.8	2.07	12.9	2.07	12.9	1.96	13.1	2.07	12.4
7	June 9	2.19	14.3	2.42	14.5	2.30	14.6	2.07	13.1	2.07	12.7
8	June 16	2.65	16.4	2.76	16.2	3.45	21.8	2.53	15.8	2.07	15.0
9	June 24	2.88	17.4	2.88	17.5	2.88	18.2	2.65	16.3	2.42	15.0
10	June 30	2.65	15.3	2.53	15.4	2.76	15.9	2.53	15.1	2.53	14.6
11	July 8	2.53	15.2	2.53	15.0	2.53	15.0	2.42	14.0	2.53	14.8
12	July 14	2.53	14.6	2.53	14.5	2.53	15.4	2.76	15.4	2.65	15.3
13	July 21	2.53	15.7	2.53	15.7	2.65	15.1	2.30	14.2	2.19	13.6
14	July 28	1.73	10.2	1.73	10.2	1.84	10.5	1.73	10.0	1.73	10.1
15	August 5	1.96	11.0	1.84	11.0	1.84	10.8	1.96	11.2	1.84	10.5
16	August 11	1.84	11.6	1.96	11.5	1.96	11.8	1.84	11.4	1.84	11.0
18	August 27	1.73	11.0	1.50	8.7	2.07	12.0	1.96	11.7	2.19	12.7
	Sum	34.20	209.50	34.65	209.10	36.37	222.10	33.86	208.00	32.46	198.00
	Average	2.14	13.09	2.17	13.07	2.27	13.88	2.12	13.00	2.03	12.38

SECOND FOOT.

1	May 1	3.34	18.1	3.22	16.9	3.34	18.5	2.99	20.0	2.99	17.7
3	May 12	2.42	14.7	2.65	15.9	2.76	16.3	2.76	15.8	2.53	15.8
5	May 26	2.99	17.0	2.88	16.4	3.11	18.4	2.88	17.0	2.99	16.7
7	June 9	2.76	16.4	2.88	16.4	2.99	17.8	2.88	17.6	3.11	16.9
9	June 24	3.57	21.1	3.80	20.9	3.91	21.4	3.34	18.1	3.11	17.4
11	July 8	2.99	17.8	3.11	18.6	2.99	18.2	3.22	18.8	3.22	17.6
13	July 21	3.11	17.5	3.22	17.9	3.34	18.7	3.45	18.0	3.57	18.9
15	August 5	2.30	12.5	2.42	13.0	2.65	13.6	2.76	15.7	2.76	15.7
18	August 27	2.65	15.2	2.42	14.5	2.99	18.0	3.11	17.5	2.88	17.2
	Sum	26.13	150.30	26.60	150.50	28.08	160.90	27.39	158.50	27.16	153.90
	Average	2.90	16.70	2.96	16.72	3.12	17.88	3.04	17.61	3.02	17.10

THIRD FOOT.

1	May 1	3,91	20.1	3.22	16.9	3.80	19.3	3.91	20.8	3.91	19.6
9	June 24	3.80	20.2	4.14	21.7	3.91	20.9	3.45	17.0	3.45	15.5
18	August 27	3.22	16.7	2.88	14.6	3.34	17.5	2.76	14.7	3.34	17.3
	Sum	10.93	57.00	10.24	53.20	11.05	57.70	10.12	52.5	10.70	52.4
	Average	3.64	18.66	3.41	17.73	3.68	19.23	3.37	17.5	3.57	17.47

FOURTH FOOT.

1	May 1	2.99	15.9	2.19	12.5	2.30	12.8	3.34	16.2	2.99	16.9
9	June 24	3.34	17.1	3.45	19.5	3.57	17.8	3.22	16.5	3.11	16.5
18	August 27	2.65	14.5	3.22	18.2	1.84	9.2	1.96	11.0	2.53	13.7
	Sum	8.98	47.5	8.86	50.20	7.71	39.80	8.52	43.7	8.63	47.1
	Average	2.99	15.83	2.95	16.73	2.57	13.27	2.84	14.57	2.88	15.7

Soil moisture in sassafras sandy loam at Marlboro, Md., under fallow, with 5 grades of fertilization—1903.

FIRST FOOT.

Period.	Date.	Moisture in soil to which was added per acre—Nothing.		5 tons manure.		10 tons manure.		15 tons manure.		300 pounds guano.	
		Inches.	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*
1	May 1	2.42	16.3	2.53	16.8	2.65	17.5	2.53	17.00	2.30	15.8
3	May 12	2.07	13.5	2.07	14.6	2.30	15.4	2.30	15.4	2.19	14.4
4	May 18	2.07	14.3	2.19	14.3	2.19	14.5	2.19	15.1	2.07	14.1
5	May 26	2.07	13.6	2.30	15.5	2.30	15.6	2.07	15.0	2.19	14.4
6	June 1	2.76	17.8	2.76	18.6	2.65	18.7	2.65	18.1	2.88	18.8
7	June 9	2.42	15.7	2.76	17.3	2.53	17.1	2.76	18.2	2.42	15.7
8	June 16	2.65	18.4	2.88	19.1	2.88	19.8	2.65	18.4	2.88	19.8
9	June 24	2.42	18.1	2.76	18.5	2.53	19.0	2.76	19.0	2.99	19.8
10	June 30	2.76	18.0	2.88	18.9	2.99	19.5	3.22	20.7	3.34	20.7
11	July 8	2.65	16.3	2.53	15.5	2.53	16.4	2.65	16.9	2.53	16.1
12	July 14	3.34	20.0	3.22	20.0	3.22	20.3	3.22	20.4	3.11	20.0
13	July 21	2.42	16.4	2.65	17.3	2.65	16.8	2.30	14.9	2.07	14.0
14	July 28	1.61	9.7	1.61	9.5	1.96	12.25	1.73	10.5	1.96	12.3
15	August 5	2.19	13.7	2.19	14.0	2.42	15.0	2.42	15.2	2.30	14.5
16	August 11	2.65	16.2	2.65	16.5	2.65	17.0	2.76	17.0	2.65	17.0
18	August 27	2.76	18.1	2.07	12.8	2.19	13.8	2.07	12.8	2.19	13.8
	Sum	39.26	256.10	40.05	259.20	40.64	269.05	40.30	264.60	40.07	261.20
	Average	2.45	16.01	2.50	16.20	2.54	16.82	2.52	16.54	2.51	16.33

SECOND FOOT.

1	May 1	3.57	21.7	3.34	21.3	3.34	23.0	3.57	21.1	3.45	21.6
3	May 12	3.22	19.2	3.22	19.6	2.99	18.8	3.22	19.6	2.88	19.1
5	May 26	2.99	17.3	3.11	18.7	3.11	18.4	3.11	18.6	2.88	16.8
7	June 9	2.65	17.3	2.88	18.2	3.22	19.7	2.99	17.8	2.88	18.4
9	June 24	3.57	22.5	3.57	21.8	3.57	22.3	2.99	19.7	3.22	18.5
11	July 8	3.11	18.8	3.22	19.2	3.34	20.0	3.34	19.7	3.34	19.9
13	July 21	2.53	15.1	2.53	15.9	2.42	15.8	2.42	13.6	2.88	17.5
15	August 5	2.88	16.0	2.88	16.9	2.99	17.7	3.11	17.8	3.11	18.0
18	August 27	2.30	14.8	2.76	17.5	2.47	14.3	2.65	16.6	2.30	14.0
	Sum	26.82	162.70	27.51	169.10	27.45	170.00	27.40	164.50	27.24	163.80
	Average	2.98	18.08	3.06	18.79	3.05	18.89	3.04	18.28	3.03	18.20

THIRD FOOT.

1	May 1	3.80	24.2	4.48	24.8	4.03	25.7	4.26	24.0	4.14	25.1
9	June 24	3.68	21.8	4.14	24.5	4.14	23.8	4.03	23.3	4.14	25.2
18	August 27	2.99	17.0	3.40	19.0	2.30	12.3	3.22	18.3	3.11	18.3
	Sum	10.47	63.00	12.02	68.3	10.47	61.80	11.57	65.60	11.39	68.60
	Average	3.49	21.00	4.00	22.77	3.49	20.6	3.83	21.87	3.80	22.87

FOURTH FOOT.

1	May 1	4.95	29.6	4.60	29.0	4.60	27.2	4.60	27.8	4.37	27.9
9	June 24	4.14	24.2	4.37	26.6	4.26	25.5	4.60	26.1	4.83	26.0
18	August 27	2.99	16.0	3.22	18.1	3.11	18.7	3.34	18.5	4.37	25.5
	Sum	12.08	69.80	12.19	73.70	11.97	71.40	12.54	72.40	13.57	79.40
	Average	4.03	23.26	4.06	24.57	3.99	23.80	4.18	24.13	4.52	26.47

Soil moisture in Norfolk sand at Marlboro, Md., under potatoes, with 5 grades of fertilization—1903.

FIRST FOOT.

Period.	Date.	Moisture in soil to which was added per acre—									
		Nothing.		5 tons manure.		10 tons manure.		15 tons manure.		300 pounds guano.	
		Inches.	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*
1	April 29........	2.19	12.8	2.07	12.8	2.19	13.4	2.42	13.6	2.19	12.8
3	May 12..........	1.73	10.6	1.50	9.9	1.73	10.5	1.84	11.1	1.73	10.6
4	May 18..........	1.38	8.9	1.38	8.8	1.50	9.6	1.73	10.9	1.38	8.9
5	May 25..........	2.07	12.5	2.07	12.7	2.07	12.6	2.19	13.2	2.19	13.8
6	June 1..........	1.96	12.8	1.84	12.0	1.96	12.3	1.96	12.3	1.96	11.3
7	June 8..........	2.30	13.9	2.30	13.9	2.53	15.4	2.42	14.2	2.42	14.8
8	June 17.........	2.99	16.9	2.88	16.7	2.99	17.2	2.99	17.3	3.11	18.4
9	June 24.........	2.88	16.8	2.76	17.5	3.34	18.4	3.22	18.8	3.11	19.6
10	June 30.........	2.76	16.3	2.65	16.3	2.65	16.8	2.65	16.9	2.76	16.8
11	July 8..........	2.53	15.1	2.30	13.7	2.53	15.0	2.30	13.7	2.53	14.8
12	July 14.........	2.53	15.7	2.42	14.9	2.42	14.9	2.53	15.4	2.76	16.7
13	July 23.........	2.88	18.4	2.76	16.9	2.76	17.4	2.76	17.9	2.88	18.2
14	July 28.........	1.27	7.8	1.15	7.0	1.15	7.1	1.15	6.7	1.38	8.5
15	August 5........	1.27	7.8	1.38	8.1	1.04	6.2	1.27	7.5	1.38	8.3
16	August 12.......	1.44	13.0	1.46	13.0	1.45	13.0	1.48	13.0	1.37	14.0
18	August 26.......	1.27	7.7	1.73	10.7	1.50	9.2	1.61	10.0	2.19	12.8
	Sum	33.45	207.00	32.65	204.9	33.81	209.6	34.52	212.5	35.34	220.3
	Average ..	2.09	12.94	2.04	12.81	2.11	13.1	2.16	13.28	2.21	13.77

SECOND FOOT.

Period.	Date.	Nothing. Inches.	Nothing. Per ct.	5 tons manure. Inches.	5 tons manure. Per ct.	10 tons manure. Inches.	10 tons manure. Per ct.	15 tons manure. Inches.	15 tons manure. Per ct.	300 pounds guano. Inches.	300 pounds guano. Per ct.
1	April 29........	2.88	18.4	3.34	18.5	3.11	18.5	3.34	20.4	3.22	19.4
3	May 12..........	2.88	16.9	2.99	16.6	3.22	19.0	3.57	20.3	3.34	19.2
5	May 26..........	2.99	16.9	2.76	15.4	3.57	20.5	3.11	18.0	3.34	18.6
7	June 9..........	3.11	17.2	2.99	16.9	3.34	19.6	3.45	19.5	3.34	19.3
9	June 25.........	3.80	21.3	3.68	19.6	3.57	22.1	3.68	21.2	3.80	21.6
11	July 8..........	3.34	19.3	3.34	18.0	3.68	20.8	3.57	20.0	3.45	19.7
13	July 23.........	3.80	21.9	3.91	22.7	3.91	23.5	3.80	22.7	3.91	22.1
15	August 5........	2.42	13.0	2.76	16.0	2.88	15.4	2.88	16.0	3.22	18.1
18	August 26.......	2.30	13.0	1.27	7.2	2.88	16.3	2.76	15.5	2.65	15.0
	Sum	27.52	157.9	27.04	150.9	30.16	175.70	30.16	173.6	30.27	173.0
	Average ..	3.06	17.54	3.00	16.77	3.35	19.52	3.35	19.29	3.36	19.22

THIRD FOOT.

Period.	Date.	Nothing. Inches.	Nothing. Per ct.	5 tons manure. Inches.	5 tons manure. Per ct.	10 tons manure. Inches.	10 tons manure. Per ct.	15 tons manure. Inches.	15 tons manure. Per ct.	300 pounds guano. Inches.	300 pounds guano. Per ct.
1	April 29........	3.57	17.8	3.80	22.0	4.03	20.9	3.45	19.9	3.57	21.2
9	June 25.........	3.11	17.4	3.22	16.0	3.68	19.6	3.91	19.4	3.68	19.9
18	August 26.......	2.65	14.8	3.11	15.7	2.99	16.2	3.11	18.0	1.61	9.0
	Sum	9.33	50.0	10.13	53.7	10.70	56.7	10.47	57.3	8.86	50.1
	Average ..	3.11	16.67	3.38	17.9	3.57	18.9	3.49	19.1	2.95	16.7

FOURTH FOOT.

Period.	Date.	Nothing. Inches.	Nothing. Per ct.	5 tons manure. Inches.	5 tons manure. Per ct.	10 tons manure. Inches.	10 tons manure. Per ct.	15 tons manure. Inches.	15 tons manure. Per ct.	300 pounds guano. Inches.	300 pounds guano. Per ct.
1	April 29........	3.11	17.4	3.45	16.7	3.34	17.1	2.88	16.3	3.34	16.6
9	June 25.........	2.88	14.7	2.76	15.1	2.88	15.2	3.22	16.2	3.22	16.2
18	August 26.......	1.50	10.0	2.19	11.0	2.65	14.7	2.42	13.5	2.30	11.7
	Sum	7.49	42.1	8.40	42.8	8.87	47.0	8.52	46.0	8.86	44.5
	Average ..	2.49	14.03	2.80	14.26	2.96	15.67	2.84	15.33	2.95	14.83

Soil moisture in Sassafras sandy loam at Marlboro, Md., under potatoes, with 5 grades of fertilization—1903.

FIRST FOOT.

Period.	Date.	Moisture in soil to which was added per acre—									
		Nothing.		5 tons manure.		10 tons manure.		15 tons manure.		300 pounds guano.	
		Inches.	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*
1	April 29........	2.19	15.3	2.42	15.9	2.19	16.1	2.19	17.0	1.73	15.3
3	May 12..........	2.19	14.0	2.19	14.4	2.07	13.6	2.42	15.8	2.19	14.9
4	May 18..........	1.96	12.9	2.53	15.7	2.07	13.5	1.96	13.7	2.30	14.3
5	May 25..........	2.07	14.4	2.19	14.4	2.19	14.3	2.19	14.5	2.19	14.3
6	June 1..........	1.84	17.4	2.65	17.7	2.42	17.6	2.07	17.7	2.07	17.7
7	June 8..........	2.42	16.0	2.53	15.9	2.30	15.6	2.53	16.1	2.42	16.3
8	June 17.........	2.76	18.7	2.53	17.7	2.65	17.7	2.65	18.4	2.99	18.3
9	June 24.........	2.76	17.8	2.76	17.3	2.55	16.5	2.65	18.1	2.99	19.5
10	June 30.........	2.76	18.6	2.88	19.2	2.88	18.2	2.76	17.9	2.99	19.0
11	July 8...........	1.73	12.5	2.19	13.9	2.07	13.2	2.07	13.5	2.30	14.5
12	July 14..........	2.99	19.4	2.76	18.5	2.76	18.2	2.53	17.9	2.99	19.5
13	July 23..........	2.30	15.3	2.19	14.6	2.07	14.3	2.19	15.1	2.19	14.8
14	July 28..........	1.61	10.10	1.38	9.25	1.50	10.0	1.38	9.25	1.61	11.3
15	August 5........	1.84	11.75	1.61	10.75	1.84	11.5	1.61	10.5	1.96	12.5
16	August 12......	1.32	20.00	1.30	20.00	1.28	19.0	1.28	19.0	1.32	20.0
18	August 26......	1.73	11.00	1.61	10.50	1.50	10.0	1.73	10.8	1.78	11.0
	Sum	34.47	245.15	35.72	238.80	34.34	240.3	34.21	243.25	36.02	253.2
	Average .	2.19	15.32	2.23	14.92	2.15	15.02	2.14	15.20	2.25	15.83

SECOND FOOT.

1	April 29........	3.22	20.1	3.22	19.7	3.34	19.0	3.34	21.0	3.22	20.4
3	May 12..........	3.22	19.9	3.22	19.3	3.34	19.1	3.11	18.2	3.22	19.3
5	May 26..........	3.11	17.7	2.99	17.9	2.99	17.8	2.88	16.9	2.99	17.7
7	June 9..........	2.76	17.4	2.88	18.1	2.99	18.6	2.88	17.9	2.88	18.4
9	June 25.........	3.22	20.0	3.22	19.0	3.11	19.7	2.99	17.8	3.11	20.6
11	July 8...........	2.99	18.4	2.99	17.9	2.88	17.6	2.88	18.1	2.99	18.1
13	July 23..........	2.42	14.7	2.53	15.6	2.53	15.5	2.65	16.9	2.99	18.3
15	August 5........	2.30	12.4	2.53	14.50	2.42	13.4	2.65	14.5	2.76	16.7
18	August 26......	2.42	15.0	2.07	12.20	2.36	13.7	2.13	13.3	1.84	10.7
	Sum	25.66	155.60	25.65	154.20	25.96	154.4	25.51	154.6	26.00	160.2
	Average .	2.85	17.29	2.85	17.13	2.88	17.16	2.83	17.18	2.89	17.8

THIRD FOOT.

1	April 29........	4.03	23.2	4.03	22.9	4.26	23.5	3.91	23.7	4.14	23.8
9	June 25.........	3.80	21.7	3.34	20.1	3.91	21.8	3.80	21.0	4.03	22.4
18	August 26......	2.88	16.5	2.76	16.0	2.99	16.7	2.65	15.0	2.42	13.0
	Sum	10.71	61.4	10.13	59.00	11.16	62.00	10.36	59.7	10.59	59.2
	Average .	3.57	20.47	3.38	19.67	3.72	20.67	3.45	19.9	3.53	19.73

FOURTH FOOT.

1	April 29........	4.37	25.7	4.26	26.1	4.83	27.3	3.80	27.0	4.49	26.2
9	June 25.........	4.03	21.7	3.57	20.5	4.03	22.2	4.14	24.5	4.72	27.0
18	August 26......	3.45	19.5	3.40	18.5	3.11	16.8	2.99	16.7	3.80	23.5
	Sum	11.85	66.9	11.23	65.1	11.97	66.3	10.93	68.2	13.01	76.7
	Average .	3.95	22.3	3.74	21.7	3.99	22.1	3.64	22.7	4.34	25.57

Soil moisture in Hagerstown clay loam at Lancaster, Pa., under corn, with 5 grades of fertilization—1903.

FIRST FOOT.

Period.	Date.	Moisture in soil to which was added per acre—									
		Nothing.		5 tons manure.		10 tons manure.		15 tons manure.		300 pounds guano.	
		Inches.	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*
1	April 29	2.42	24.42	3.86	24.23	2.36	22.53	2.51	22.59	2.70	22.17
3	May 12	2.53	20.20	2.30	21.50	2.39	20.40	2.74	21.10	2.53	21.30
4	May 18	2.36	19.90	2.43	19.10	2.30	18.66	2.56	19.91	2.73	20.64
5	May 25	2.65	20.00	2.65	20.32	2.57	20.42	2.69	19.86	2.65	21.34
6	June 1	2.60	20.70	2.73	20.88	2.73	21.29	2.53	21.83	2.80	22.82
7	June 8	3.13	22.50	2.88	23.00	3.02	22.50	3.14	23.00	3.08	24.30
8	June 16	3.59	25.70	3.35	26.20	2.96	25.50	3.37	26.20	3.13	26.10
9	June 23	2.99	25.61	3.07	26.43	2.97	24.92	3.51	26.25	3.63	26.81
10	June 30	3.40	24.60	3.40	24.20	3.36	23.60	3.26	23.20	3.57	24.70
11	July 6	3.29	23.60	3.42	24.60	3.63	25.20	3.86	29.70	3.28	25.40
12	July 13	3.81	27.20	4.29	28.20	3.65	26.90	3.74	26.70	3.99	28.00
13	July 20	3.28	25.00	3.63	25.30	3.18	23.00	3.28	25.20	3.53	26.10
14	July 27	2.59	21.05	2.90	21.00	2.84	20.75	2.96	21.00	2.84	21.00
15	August 3........	2.75	17.90	2.79	18.50	2.94	19.20	2.68	18.00	2.90	19.00
16	August 11......	3.17	21.30	2.97	21.40	3.26	22.90	3.29	25.00	3.40	24.30
18	....	3.11	22.90	2.59	21.20	3.08	21.00	3.19	22.10	2.89	21.70
	Sum	47.47	363.58	48.96	366.05	47.24	362.77	49.31	371.64	49.65	375.68
	Average .	2.97	22.72	3.06	22.88	2.95	22.67	3.08	23.23	3.10	23.48

SECOND FOOT.

1	April 29	4.03	24.56	4.22	24.39	4.32	26.98	3.86	23.18	3.89	22.65
3	May 11	3.91	22.30	3.90	22.40	3.87	22.00	4.04	22.90	3.91	21.50
5	May 18	3.73	21.57	4.17	24.49	3.79	22.01	3.63	21.65	3.91	22.11
7	June 8	3.66	21.50	3.71	22.30	3.40	19.80	3.83	21.75	3.60	21.30
9	June 23	4.09	24.41	4.51	26.08	3.83	23.58	4.53	25.78	4.35	24.78
11	July 6	4.21	24.50	4.43	26.60	4.18	23.30	4.22	23.30	3.91	23.70
13	July 20	4.49	25.00	4.51	25.50	3.97	23.10	4.59	26.60	4.06	22.30
15	August 3........	3.59	19.90	3.83	22.20	3.50	20.50	3.56	19.70	3.68	20.60
18	....	3.88	22.20	4.26	22.60	3.68	21.10	4.24	21.60	3.94	22.00
	Sum	35.59	205.94	37.54	216.56	34.54	202.37	36.50	206.56	35.25	200.94
	Average .	3.95	22.88	4.17	24.06	3.84	22.49	4.06	22.95	3.92	22.33

THIRD FOOT.

1	April 29	5.12	27.38	5.41	28.14	4.09	23.13	4.95	24.78	4.72	23.91
9	June 23	4.52	24.92	5.44	28.02	4.83	24.59	5.01	26.31	4.90	25.63
18	....	5.18	25.30	4.79	24.50	4.94	22.10	4.64	21.70	4.68	23.40
	Sum	14.82	77.60	15.64	80.66	13.86	69.82	14.60	72.79	14.30	72.94
	Average .	4.94	25.87	5.21	26.89	4.62	23.27	4.87	24.26	4.77	24.31

FOURTH FOOT.

1	April 29	4.72	26.45	5.76	27.32	5.35	24.59	4.78	23.71	5.50	25.43
9	June 23	5.29	26.09	5.11	23.61	4.95	26.51	4.66	25.27	5.70	26.08
18	....	5.90	24.40	5.66	25.40	5.04	23.40	5.01	22.80	5.33	24.80
	Sum	15.91	76.94	16.53	76.33	15.54	74.40	14.45	71.78	16.53	76.31
	Average .	5.30	25.65	5.51	25.44	5.18	24.80	4.82	23.93	5.51	25.43

Soil moisture in Hagerstown loam at Lancaster, Pa., under corn, with 5 grades of fertilization—1903.

FIRST FOOT.

Period.	Date.	Moisture in soil to which was added per acre—									
		Nothing.		5 tons manure.		10 tons manure.		15 tons manure.		300 pounds guano.	
		Inches.	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*
1	April 29	2.24	22.29	2.42	20.69	2.13	19.89	2.42	21.76	2.65	22.22
3	May 12	2.30	19.50	3.41	24.10	2.09	16.10	2.30	18.10	2.07	19.50
4	May 18	2.45	19.28	2.23	18.78	2.24	16.96	2.20	18.24	2.33	19.84
5	May 25	2.65	19.66	2.38	17.42	2.37	18.04	2.47	19.55	2.21	18.37
6	June 1	2.28	18.86	2.53	18.88	2.45	19.10	2.62	19.96	2.59	20.78
7	June 8	2.56	20.00	3.04	20.70	2.57	20.00	2.88	22.00	2.56	20.75
8	June 16	3.05	25.70	3.05	23.80	3.12	24.40	3.17	26.30	3.07	25.10
9	June 23	3.40	25.11	3.34	23.33	3.59	25.68	3.49	24.94	3.40	25.00
10	June 30	4.20	24.90	3.68	25.20	3.42	23.90	3.60	25.00	3.95	25.70
11	July 6	3.19	22.70	3.13	22.20	3.05	22.10	3.22	23.00	3.22	23.00
12	July 13	3.05	25.60	3.29	25.20	3.78	26.10	3.40	25.10	3.51	25.70
13	July 20	3.45	24.80	2.99	22.20	3.36	23.90	3.05	25.70	3.40	25.10
14	July 27	3.19	22.30	2.62	18.30	2.72	18.60	2.73	18.80	2.43	17.90
15	August 3	2.56	16.30	2.61	17.50	2.42	16.20	2.64	17.80	2.44	16.60
16	August 11	2.62	20.70	3.19	21.60	2.83	19.90	2.79	20.20	3.11	20.30
18		2.51	18.90	2.92	20.40	3.07	20.60	2.65	19.10	2.45	18.30
	Sum	45.50	344.60	46.83	340.30	45.21	330.47	45.63	345.55	45.39	346.16
	Average	2.84	21.54	2.93	21.27	2.83	20.65	2.85	21.10	2.86	21.64

SECOND FOOT.

1	April 29	3.89	24.02	3.86	23.51	3.78	21.13	3.80	21.78	3.80	24.54
3	May 11	3.69	21.80	3.87	23.10	3.61	20.10	3.34	20.10	4.57	23.20
5	May 18	4.17	22.80	4.14	24.03	3.21	20.93	3.49	20.54	3.95	21.11
7	June 8	3.57	21.50	3.71	22.95	3.63	21.60	3.91	22.00	3.91	21.50
9	June 23	4.05	24.91	5.47	23.58	3.86	23.02	4.26	24.55	4.67	26.85
11	July 6	4.28	26.30	4.78	25.90	4.18	23.10	3.74	23.80	3.81	21.00
13	July 20	4.47	25.60	4.67	25.10	4.51	24.30	4.63	24.60	4.06	24.50
15	August 3	3.50	21.40	3.95	22.30	4.18	22.50	3.90	23.90	3.60	19.20
18		3.55	22.10	4.19	23.20	4.20	23.40	3.55	20.10	3.56	20.40
	Sum	35.17	210.43	38.64	213.67	34.56	200.08	34.62	201.37	35.93	206.30
	Average	3.91	23.38	4.29	23.74	3.84	22.23	3.85	22.37	3.76	22.92

THIRD FOOT.

1	April 29	4.89	25.22	4.51	23.15	5.35	24.54	4.72	23.77	4.60	24.17
9	June 23	5.06	26.11	4.51	26.61	5.03	24.24	5.62	27.81	5.52	27.59
18		3.84	20.00	4.16	21.50	4.14	25.30	3.60	17.80	4.64	23.50
	Sum	13.79	71.33	13.18	71.26	14.52	74.08	13.94	69.38	14.76	75.26
	Average	4.60	23.78	4.39	23.42	4.84	24.69	4.65	23.13	4.92	25.09

FOURTH FOOT.

1	April 29	5.18	25.00	5.64	27.37	4.55	24.84	4.40	23.61	4.63	20.90
9	June 23	4.22	26.93	5.39	25.16	4.12	25.37	4.86	25.19	5.43	25.04
18		5.43	27.80	4.41	30.10	5.54	28.10	5.41	25.60	5.33	23.50
	Sum	14.83	79.73	15.44	82.63	14.21	78.31	14.67	74.40	15.39	69.44
	Average	4.71	26.58	5.15	27.54	4.73	26.10	4.89	24.80	5.13	23.15

Soil moisture Hagerstown clay loam at Lancaster, Pa., under fallow, with 5 grades of fertilization—1903.

FIRST FOOT.

Period.	Date.	Moisture in soil to which was added per acre—									
		Nothing.		5 tons manure.		10 tons manure.		15 tons manure.		300 pounds guano.	
		Inches.	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*
1	April 29	2.50	22.39	2.57	23.80	2.50	24.58	2.59	24.73	2.42	23.28
3	May 11	2.59	21.00	2.73	21.30	2.59	19.60	2.06	15.60	2.65	19.90
4	May 18	2.27	20.74	2.62	21.88	2.24	20.81	2.07	21.90	2.45	19.45
5	May 25	2.88	21.70	3.11	22.60	2.74	22.40	2.84	21.80	2.47	20.00
6	June 1	2.51	22.40	2.81	22.20	2.64	22.10	2.67	23.20	2.62	21.70
7	June 8	2.96	24.80	2.66	21.06	2.90	24.47	2.80	24.92	2.76	23.12
8	June 16	3.42	26.60	3.22	26.30	3.18	26.90	3.08	25.20	3.43	25.90
9	June 24	3.37	26.35	3.66	27.84	3.34	28.29	3.59	26.79	3.80	26.83
10	June 30	3.35	25.30	3.22	25.30	2.91	22.80	3.41	24.50	3.48	25.40
11	July 6	3.26	25.80	3.59	26.70	3.08	25.30	3.22	24.80	3.51	25.40
12	July 13	4.12	26.40	4.14	28.50	3.97	27.80	3.44	25.70	3.36	25.10
13	July 20	3.74	26.40	4.03	27.40	3.72	25.90	3.68	25.50	3.60	25.00
14	July 27	2.90	20.60	3.40	24.90	2.62	21.90	3.00	21.90	3.26	21.50
15	August 3	3.03	20.80	3.10	20.90	3.26	21.10	3.04	20.80	3.03	19.90
16	August 10	3.40	24.90	3.49	24.90	3.57	25.50	3.57	25.20	3.51	24.00
18	August 24	3.04	22.70	3.15	22.40	2.67	22.70	3.28	23.50	3.29	22.60
	Sum	49.34	380.88	51.50	387.98	48.03	382.23	48.34	376.04	49.64	369.08
	Average	3.08	23.81	3.22	24.25	3.00	23.89	3.02	23.50	3.10	23.07

SECOND FOOT.

Period.	Date.	Nothing. Inches.	Nothing. Per ct.	5 tons manure. Inches.	5 tons manure. Per ct.	10 tons manure. Inches.	10 tons manure. Per ct.	15 tons manure. Inches.	15 tons manure. Per ct.	300 pounds guano. Inches.	300 pounds guano. Per ct.
1	April 29	4.02	22.01	4.32	25.42	5.35	32.14	3.97	23.88	3.68	23.70
3	May 11	3.57	21.80	3.91	21.90	3.97	22.60	3.73	22.10	3.82	19.90
5	May 25	3.60	20.70	3.83	22.80	3.72	21.80	3.95	22.60	3.91	24.60
7	June 8	2.94	19.77	3.61	20.00	3.80	22.33	4.37	25.05	3.30	18.54
9	June 24	3.95	23.90	4.37	26.03	4.41	23.79	4.03	22.05	4.45	24.52
11	July 6	4.43	24.90	4.34	25.00	4.32	24.50	4.45	25.20	4.34	23.60
13	July 20	4.47	24.50	4.58	25.60	4.43	25.40	3.79	25.00	4.21	23.10
15	August 3	3.75	21.40	3.63	22.70	4.02	22.10	4.06	22.70	3.82	22.60
18	August 24	4.05	22.20	4.12	23.30	4.11	23.30	4.09	23.20	4.51	24.00
	Sum	34.78	201.18	36.71	212.75	38.13	217.96	36.44	211.78	36.04	204.56
	Average	3.86	22.35	4.08	23.64	4.24	24.22	4.05	23.53	4.00	22.72

THIRD FOOT.

Period.	Date.	Nothing. Inches.	Nothing. Per ct.	5 tons manure. Inches.	5 tons manure. Per ct.	10 tons manure. Inches.	10 tons manure. Per ct.	15 tons manure. Inches.	15 tons manure. Per ct.	300 pounds guano. Inches.	300 pounds guano. Per ct.
1	April 29	5.34	24.68	4.79	26.53	5.39	26.09	5.10	23.79	5.33	24.03
9	June 24	5.29	25.17	4.72	26.70	4.68	25.12	4.06	18.58	4.52	20.90
18	August 24	4.73	24.00	4.64	24.30	4.63	22.50	5.02	24.90	4.82	24.60
	Sum	15.36	73.85	14.15	77.53	14.70	73.71	14.18	67.27	14.67	69.53
	Average	5.12	24.62	4.72	25.84	4.90	24.57	4.73	22.42	4.89	23.18

FOURTH FOOT.

Period.	Date.	Nothing. Inches.	Nothing. Per ct.	5 tons manure. Inches.	5 tons manure. Per ct.	10 tons manure. Inches.	10 tons manure. Per ct.	15 tons manure. Inches.	15 tons manure. Per ct.	300 pounds guano. Inches.	300 pounds guano. Per ct.
1	April 29	5.28	26.30	5.78	28.23	4.83	25.45	5.73	28.06	6.09	26.99
9	June 24	5.66	28.52	5.79	28.33	5.79	26.12	5.18	26.17	5.19	21.32
18	August 24	5.23	24.90	5.78	26.60	5.19	23.20	5.56	25.50	5.79	25.50
	Sum	16.17	79.72	17.35	83.16	15.81	74.77	16.47	79.73	17.07	73.81
	Average	5.39	26.57	5.78	27.72	5.27	24.92	5.49	26.58	5.69	24.60

Soil moisture in Hagerstown loam at Lancaster, Pa., under fallow, with 5 grades of fertilization—1903.

FIRST FOOT.

Period.	Date.	Moisture in soil to which was added per acre—									
		Nothing.		5 tons manure.		10 tons manure.		15 tons manure.		300 pounds guano.	
		Inches.	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*
1	April 29	2.53	21.89	2.47	21.29	2.65	20.72	2.05	19.10	2.70	22.82
3	May 11	2.56	18.10	2.53	19.00	2.30	19.60	2.42	17.50	2.39	18.70
4	May 18	2.45	19.10	2.65	19.70	2.42	18.60	2.49	19.30	2.13	17.60
5	May 25	2.88	20.20	2.37	18.00	2.30	17.10	2.47	19.30	2.51	18.30
6	June 1	2.72	20.20	2.70	20.30	2.65	19.70	2.67	20.20	2.68	19.40
7	June 8	2.82	21.00	2.97	21.50	2.70	21.50	2.59	19.00	2.94	21.20
8	June 16	3.36	24.00	3.30	24.20	3.31	23.90	3.30	23.60	3.28	23.50
9	June 24	4.09	27.24	3.31	25.37	3.83	26.70	3.76	26.06	3.45	24.69
10	June 30	3.68	25.80	3.82	25.60	3.80	25.90	3.95	26.20	3.63	24.80
11	July 6	3.19	22.70	2.97	22.30	2.86	21.20	3.55	24.00	2.76	20.60
12	July 13	4.03	27.20	3.94	27.30	3.49	25.50	3.38	25.10	3.41	24.40
13	July 20	3.81	25.30	3.80	25.50	3.80	27.00	3.56	23.50	3.30	23.20
14	July 27	3.08	21.20	3.00	20.40	2.87	19.30	3.43	23.90	3.03	19.80
15	August 3	3.25	22.50	3.37	24.40	3.68	24.50	3.28	24.80	3.72	24.60
16	August 10	3.57	22.60	3.37	22.30	3.31	22.00	3.68	23.50	3.61	22.90
18	August 24	3.12	21.70	3.15	21.40	3.37	22.40	4.02	24.90	4.17	26.60
	Sum	51.14	360.74	49.72	358.56	49.34	355.67	50.60	359.96	49.71	353.11
	Average	3.20	22.55	3.11	22.41	3.08	22.23	3.16	22.50	3.11	22.07

SECOND FOOT.

1	April 29	3.80	22.68	3.05	21.54	3.80	22.60	3.75	23.39	3.73	23.46
3	May 11	3.78	22.40	3.49	21.80	3.57	21.20	3.40	20.70	3.56	20.40
5	May 25	3.76	21.70	3.25	19.70	3.34	20.30	3.97	22.10	3.65	22.00
7	June 8	2.65	14.00	3.55	21.25	2.70	15.10	3.64	19.80	3.43	20.80
9	June 24	4.49	26.80	3.80	24.18	4.25	24.23	4.32	22.80	4.03	24.56
11	July 6	2.80	22.50	3.80	23.10	3.72	22.30	4.26	25.10	3.72	22.40
13	July 20	4.18	24.60	4.10	22.30	3.97	24.40	4.21	24.00	4.20	23.30
15	August 3	3.51	20.50	3.51	20.40	3.76	20.90	3.73	24.00	3.64	20.30
18	August 24	3.86	21.90	3.87	20.50	3.12	16.30	3.27	17.00	3.97	19.70
	Sum	32.83	197.08	32.42	194.77	32.23	187.33	34.55	198.89	33.93	196.92
	Average	3.65	21.90	3.60	21.64	3.58	20.81	3.84	22.10	3.77	21.88

THIRD FOOT.

1	April 29	4.89	24.93	3.86	21.24	5.17	27.98	5.61	27.44	4.41	24.84
9	June 24	5.72	29.06	4.12	27.54	5.73	25.91	5.24	24.07	4.81	24.70
18	August 24	4.53	23.30	4.19	19.80	5.27	24.30	5.46	27.70	7.72	38.80
	Sum	15.14	77.29	12.17	68.58	16.17	78.19	16.31	79.21	16.94	88.34
	Average	5.05	25.76	4.06	22.86	5.39	26.06	5.44	26.40	5.65	29.45

FOURTH FOOT.

1	April 29	5.35	23.72	5.70	22.30	5.49	28.82	6.12	25.89	5.32	27.75
9	June 24	5.21	28.49	5.47	22.84	6.88	27.60	5.70	22.58	5.81	27.15
18	August 24	5.09	26.80	5.32	24.50	6.77	27.30	6.30	31.20	4.64	21.80
	Sum	15.65	79.01	16.49	69.64	19.14	83.72	18.12	79.67	15.77	76.70
	Average	5.22	26.34	5.50	23.21	6.38	27.91	6.04	26.56	5.26	25.57

Soil moisture in Hagerstown clay loam, at Lancaster, Pa., under potatoes, with 5 grades of fertilization—1903.

FIRST FOOT.

Period.	Date.	Moisture in soil to which was added per acre— Nothing.		5 tons manure.		10 tons manure.		15 tons manure.		300 pounds guano.	
		Inches.	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*
1	May 1..........	2.65	23.83	2.59	23.81	2.30	23.26	2.42	23.73	2.24	23.41
3	May 12.........	2.86	22.50	2.51	21.70	2.65	21.30	2.64	22.10	3.30	26.10
4	May 18.........	2.76	21.00	2.57	20.60	2.69	21.50	2.59	22.30	2.46	18.30
5	May 25.........	2.99	22.30	2.69	22.40	2.60	22.80	2.75	21.40	2.76	22.10
6	June 1.........	2.74	23.00	2.68	23.30	2.77	21.80	2.98	23.30	2.74	22.60
7	June 9.........	2.92	24.90	3.19	24.60	3.36	25.30	3.02	25.40	2.65	22.80
8	June 15........	3.45	26.10	3.55	27.90	3.42	26.60	3.22	26.80	3.35	26.60
9	June 24........	3.80	27.16	3.72	29.16	3.57	27.31	3.94	27.14	4.16	27.92
10	June 30........	3.99	28.30	3.34	27.00	3.57	26.50	3.22	22.70	2.65	18.70
11	July 7.........	3.28	24.60	3.30	26.10	3.40	25.10	3.05	24.90	3.11	24.70
12	July 13........	3.51	27.90	3.72	25.70	3.86	27.50	3.89	27.70	3.63	26.90
13	July 21........	3.21	25.70	3.65	26.60	3.53	25.30	3.67	27.50	3.71	26.00
14	July 27........	2.84	21.40	2.68	20.80	2.76	21.30	2.70	19.70	2.70	20.10
15	August 4.......	2.24	17.50	2.28	17.10	2.36	16.60	2.45	17.30	2.47	17.40
16	August 10......	3.48	25.00	3.42	23.60	3.51	24.40	2.99	21.50	3.28	23.40
18	August 25......	2.89	22.10	2.72	22.00	3.07	21.50	3.25	21.80	2.88	21.00
	Sum.....	49.61	383.29	48.61	382.37	49.42	379.07	48.78	375.27	48.09	368.03
	Average.	3.10	23.96	3.04	23.90	3.09	23.69	3.05	24.45	3.01	23.00

SECOND FOOT.

Period.	Date.	Nothing. Inches.	Per ct.	5 tons manure. Inches.	Per ct.	10 tons manure. Inches.	Per ct.	15 tons manure. Inches.	Per ct.	300 pounds guano. Inches.	Per ct.
1	May 1..........	4.17	24.63	4.09	24.40	3.44	22.91	3.97	22.77	3.86	23.10
3	May 11.........	3.75	22.20	3.83	22.30	4.11	25.00	3.66	22.00	3.55	22.60
5	May 25.........	4.11	23.50	4.21	24.00	3.94	22.20	3.90	22.20	3.86	22.20
7	June 9.........	3.43	21.30	3.17	19.30	3.83	21.90	3.76	22.20	3.72	21.60
9	June 24........	4.45	26.33	3.23	17.32	3.78	21.37	3.25	16.10	3.89	23.47
11	July 7.........	3.83	21.00	4.18	24.30	3.88	23.80	3.72	21.80	4.28	23.70
13	July 21........	3.91	23.80	4.30	25.50	4.30	25.20	4.50	24.70	3.92	23.60
15	August 4.......	3.65	20.10	3.66	19.90	3.29	19.70	3.30	19.10	3.58	20.40
18	August 25......	3.78	22.00	3.94	16.30	3.76	20.70	4.01	21.70	4.09	23.30
	Sum.....	35.08	204.86	34.61	193.32	34.33	202.78	34.07	192.57	34.75	203.97
	Average.	3.90	22.76	3.85	21.48	3.81	22.53	3.79	21.40	3.86	22.66

THIRD FOOT.

Period.	Date.	Nothing. Inches.	Per ct.	5 tons manure. Inches.	Per ct.	10 tons manure. Inches.	Per ct.	15 tons manure. Inches.	Per ct.	300 pounds guano. Inches.	Per ct.
1	May 1..........	4.63	23.24	4.66	24.37	3.66	21.63	5.24	25.78	4.34	24.72
9	June 24........	5.89	26.09	5.01	22.89	5.25	24.29	4.47	24.02	4.70	24.77
18	August 25......	4.93	23.00	4.70	23.50	5.35	23.50	4.75	24.30	4.81	23.00
	Sum.....	15.45	72.33	14.37	70.76	14.26	69.42	14.46	74.10	13.85	72.49
	Average.	5.15	24.11	4.79	23.59	4.75	23.14	4.82	24.70	4.62	24.16

FOURTH FOOT.

Period.	Date.	Nothing. Inches.	Per ct.	5 tons manure. Inches.	Per ct.	10 tons manure. Inches.	Per ct.	15 tons manure. Inches.	Per ct.	300 pounds guano. Inches.	Per ct.
1	May 1..........	5.52	24.37	5.27	24.86	5.87	27.27	5.47	25.82	5.01	26.44
9	June 24........	4.96	20.07	5.43	24.87	5.33	26.73	5.12	22.12	4.57	24.51
18	August 25......	4.87	20.50	4.74	23.30	5.46	25.50	5.09	24.50	5.26	23.50
	Sum.....	15.35	64.94	15.44	73.03	16.66	79.50	15.68	72.44	14.84	74.45
	Average.	5.12	21.65	5.15	24.34	5.55	26.50	5.23	24.15	4.95	24.82

Soil moisture in Hagerstown loam at Lancaster, Pa., under potatoes, with 5 grades of fertilization—1903.

FIRST FOOT.

Period.	Date.	Moisture in soil to which was added per acre—									
		Nothing.		5 tons manure.		10 tons manure.		15 tons manure.		300 pounds guano.	
		Inches.	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*
1	May 1	2.39	21.40	2.53	19.38	2.70	20.80	2.66	20.10	2.47	19.82
3	May 11	2.36	17.10	2.47	18.30	2.81	18.90	2.45	17.40	2.23	16.30
4	May 18	2.36	17.60	2.57	19.10	2.61	18.40	2.79	19.60	2.70	18.40
5	May 25	2.28	17.50	2.47	17.80	2.62	18.70	2.62	16.50	2.76	17.50
6	June 1	2.45	18.10	2.76	20.00	2.91	20.80	2.86	21.20	2.67	19.50
7	June 9	2.97	21.10	3.05	21.40	2.80	19.80	2.44	16.75	2.90	20.00
8	June 15	3.45	24.60	3.60	24.60	3.34	23.70	3.34	24.50	3.48	23.70
9	June 24	3.45	24.10	3.20	23.03	3.89	25.76	3.80	25.88	3.31	23.38
10	June 30	3.86	26.10	3.68	25.40	3.91	25.00	3.71	26.20	3.95	26.00
11	July 7	2.86	20.80	3.03	23.10	3.08	20.70	3.28	21.80	3.11	20.70
12	July 13	3.71	24.90	3.74	25.80	3.87	25.70	3.60	25.00	3.49	24.00
13	July 21	3.25	23.20	4.52	23.90	3.60	23.80	3.42	24.00	3.26	22.50
14	July 27	2.56	18.20	2.88	19.10	2.76	18.60	2.88	20.00	2.83	18.40
15	August 4	3.11	22.30	3.29	22.70	2.88	20.20	3.45	23.20	3.22	21.60
16	August 10	3.11	21.70	3.35	22.60	3.13	20.20	2.72	20.10	2.94	19.90
18	August 25	3.92	26.70	2.99	20.50	3.89	25.50	4.12	26.30	3.79	26.40
	Sum	47.09	345.40	50.13	346.71	50.40	346.56	50.14	350.53	49.11	338.10
	Average	2.95	21.59	3.14	21.67	3.15	21.66	3.13	21.90	3.07	21.13

SECOND FOOT.

Period.	Date.	Nothing. Inches.	Nothing. Per ct.	5 tons manure. Inches.	5 tons manure. Per ct.	10 tons manure. Inches.	10 tons manure. Per ct.	15 tons manure. Inches.	15 tons manure. Per ct.	300 pounds guano. Inches.	300 pounds guano. Per ct.
1	May 1	3.68	22.30	4.01	22.64	3.99	23.29	4.25	23.12	4.01	22.89
3	May 11	3.66	19.20	3.28	20.20	3.96	21.80	4.02	22.40	4.32	24.80
5	May 25	3.56	18.50	4.07	23.20	3.96	21.00	4.01	20.90	3.72	22.40
7	June 9	3.63	20.22	3.49	21.64	4.03	22.80	3.71	21.50	3.87	21.00
9	June 24	4.14	21.75	4.50	23.32	4.22	24.63	4.66	25.16	4.60	23.46
11	July 7	3.80	21.90	4.09	24.00	4.18	22.80	4.20	23.40	3.80	22.50
13	July 21	3.95	22.40	4.58	24.30	4.59	24.40	4.37	23.90	4.43	24.40
15	August 4	3.55	20.20	3.40	17.70	3.83	20.30	3.43	20.10	4.01	21.50
18	August 25	3.96	24.00	4.90	24.50	3.48	20.80	4.20	23.00	4.42	23.70
	Sum	33.93	190.47	36.32	201.50	36.24	201.82	36.85	203.48	37.18	206.65
	Average	3.77	21.16	4.03	22.39	4.03	25.76	4.09	22.60	4.13	22.96

THIRD FOOT.

Period.	Date.	Nothing. Inches.	Nothing. Per ct.	5 tons manure. Inches.	5 tons manure. Per ct.	10 tons manure. Inches.	10 tons manure. Per ct.	15 tons manure. Inches.	15 tons manure. Per ct.	300 pounds guano. Inches.	300 pounds guano. Per ct.
1	May 1	4.89	25.60	4.79	26.13	4.71	26.66	4.24	26.06	4.86	27.23
9	June 24	5.93	27.07	4.06	21.86	5.78	28.15	5.55	26.01	5.19	23.84
18	August 25	4.58	24.80	5.13	24.50	4.87	23.80	5.23	23.70	4.17	22.30
	Sum	15.40	77.47	13.98	72.49	15.36	78.61	15.02	75.77	14.22	73.37
	Average	5.13	25.82	4.66	24.16	5.12	26.20	5.01	25.26	4.74	24.46

FOURTH FOOT.

Period.	Date.	Nothing. Inches.	Nothing. Per ct.	5 tons manure. Inches.	5 tons manure. Per ct.	10 tons manure. Inches.	10 tons manure. Per ct.	15 tons manure. Inches.	15 tons manure. Per ct.	300 pounds guano. Inches.	300 pounds guano. Per ct.
1	May 1	5.16	27.48	6.18	24.69	5.44	25.93	5.81	29.28	5.01	28.43
9	June 24	5.49	28.39	4.93	23.65	7.10	29.81	5.66	26.41	4.87	25.25
18	August 25	5.84	23.70	4.90	23.50	6.01	30.10	5.18	22.20	3.65	18.80
	Sum	16.49	79.57	16.01	71.84	18.55	85.84	16.65	77.89	13.53	72.48
	Average	5.50	26.52	5.34	23.95	6.18	28.61	5.55	25.96	4.51	24.16

Soil moisture in Janesville loam at Janesville, Wis., under corn, with 5 grades of fertilization—1903.

FIRST FOOT.

Period.	Date.	Moisture in soil to which was added per acre—									
		Nothing.		5 tons manure.		10 tons manure.		15 tons manure.		300 pounds guano.	
		Inches.	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*
1	April 29	3.45	25.86	3.46	26.64	3.10	25.59	2.90	25.85	3.75	28.89
3	May 11	3.26	27.85	3.34	27.36	3.45	27.91	2.88	28.73	3.34	28.43
4	May 19	2.92	24.26	2.98	25.54	3.02	27.93	3.48	28.14	2.95	25.51
5	May 25	3.10	24.58	3.15	26.27	3.31	27.29	3.40	26.41	2.99	26.89
6	June 1	3.36	26.89	2.98	26.56	3.80	30.81	3.75	30.90	3.82	29.83
7	June 8	3.98	30.30	3.44	27.23	3.48	26.61	3.68	29.22	3.60	27.65
8	June 15	3.55	26.15	3.56	25.88	3.57	25.79	4.04	30.84	3.35	24.33
9	June 22	3.55	26.32	3.52	27.34	3.63	25.53	3.57	27.12	3.66	27.41
10	June 29	3.11	23.08	2.99	22.90	3.34	24.72	3.25	24.74	3.29	25.04
11	July 6	4.06	30.10	3.82	27.80	3.96	29.90	3.82	27.10	3.76	28.80
12	July 13	3.67	28.80	3.53	26.80	3.36	23.60	3.88	30.20	3.43	24.90
13	July 20	4.04	29.90	4.04	29.70	4.01	30.70	4.06	29.40	3.74	29.80
14	July 27	3.60	27.40	3.55	27.00	3.31	25.30	3.68	27.60	3.36	25.50
15	August 3	3.41	25.00	3.27	24.70	3.34	26.11	3.45	26.50	3.51	25.80
16	August 10	3.73	28.30	3.72	27.00	3.64	27.00	3.68	27.00	3.94	28.80
18	August 24	3.48	25.50	3.80	27.40	3.78	26.60	3.78	28.00	3.80	26.60
	Sum	56.27	430.29	55.15	426.12	56.10	431.39	57.30	457.75	56.29	434.18
	Average	3.52	26.89	3.45	26.63	3.51	26.96	3.58	28.61	3.52	27.14

SECOND FOOT.

Period.	Date.	Nothing: Inches.	Per ct.	5 tons: Inches.	Per ct.	10 tons: Inches.	Per ct.	15 tons: Inches.	Per ct.	Guano: Inches.	Per ct.
1	April 29	3.63	21.14	3.19	20.03	3.27	19.87	4.14	26.49	3.96	25.13
3	May 11	3.36	22.29	3.43	22.46	3.22	22.58	3.43	22.24	3.40	21.69
5	May 25	3.20	20.33	3.12	20.09	3.17	16.32	3.29	21.09	3.20	20.14
7	June 8	3.20	21.19	3.42	21.92	3.58	22.18	3.72	23.63	3.36	21.16
9	June 22	3.23	20.68	3.17	20.22	3.14	20.69	3.29	21.85	3.19	21.08
11	July 6	3.82	23.50	3.80	24.80	3.66	22.60	3.49	22.90	3.68	22.80
13	July 20	3.63	22.90	3.64	23.20	3.53	21.70	3.50	22.90	3.42	21.40
15	August 3	3.20	20.30	3.18	20.90	3.13	20.10	3.10	19.10	3.30	20.40
18	August 24	3.08	19.20	3.55	22.10	3.20	19.10	2.88	18.30	3.22	20.40
	Sum	30.35	191.53	30.50	195.72	29.90	185.14	30.84	198.50	30.73	194.20
	Average	3.37	21.28	3.39	21.75	3.32	20.57	3.43	22.06	3.41	21.58

THIRD FOOT.

Period.	Date.	Nothing: Inches.	Per ct.	5 tons: Inches.	Per ct.	10 tons: Inches.	Per ct.	15 tons: Inches.	Per ct.	Guano: Inches.	Per ct.
1	April 29	3.96	23.37	3.52	20.29	3.22	20.60	4.50	25.74	4.26	25.50
9	June 22	3.52	23.01	3.29	20.52	3.57	21.24	3.58	21.58	3.50	21.26
18	August 24	3.31	18.60	3.15	18.50	3.48	20.20	2.99	16.10	3.40	19.60
	Sum	10.79	64.98	9.96	59.31	10.27	62.04	11.07	63.42	11.16	66.36
	Average	3.60	21.66	3.32	19.77	3.42	20.68	3.69	21.14	3.72	22.12

FOURTH FOOT.

Period.	Date.	Nothing: Inches.	Per ct.	5 tons: Inches.	Per ct.	10 tons: Inches.	Per ct.	15 tons: Inches.	Per ct.	Guano: Inches.	Per ct.
1	April 29	4.66	26.56	4.36	23.79	3.88	19.21	4.49	24.24	5.17	28.73
9	June 22	3.05	16.14	4.35	24.26	4.17	22.94	4.28	24.23	4.41	24.82
18	August 24	3.22	17.20	3.52	18.10	3.82	19.50	3.72	19.00	4.47	24.30
	Sum	10.93	59.90	12.23	66.15	11.87	61.55	12.49	67.47	14.05	77.85
	Average	3.64	19.97	4.08	22.05	3.96	20.52	4.16	22.49	4.68	25.95

Soil moisture in Miami loam at Janesville, Wis., under corn, with 5 grades of fertilization—1903.

FIRST FOOT.

Period.	Date.	Moisture in soil to which was added per acre—									
		Nothing.		5 tons manure.		10 tons manure.		15 tons manure.		300 pounds guano.	
		Inches.	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*
1	April 29	2.68	20.17	3.76	20.27	2.36	20.92	2.65	21.10	2.59	19.82
3	May 11	2.58	19.18	2.62	19.86	2.58	19.08	2.52	19.83	2.43	18.92
4	May 19	2.28	17.04	2.46	18.05	2.33	18.02	2.29	14.75	2.22	16.75
5	May 25	3.08	23.43	3.20	24.28	3.18	24.04	3.20	24.62	3.17	24.08
6	June 1	2.97	22.16	2.89	21.73	3.00	22.75	2.75	22.27	3.08	22.75
7	June 8	2.89	19.43	2.90	19.60	2.66	17.50	4.36	30.70	4.51	31.30
8	June 15	2.89	19.34	2.86	19.05	2.83	18.04	2.77	18.37	2.76	18.07
9	June 22	2.86	19.45	2.72	18.22	2.51	16.64	2.64	17.35	2.56	16.58
10	June 29	2.61	17.39	2.70	17.87	2.40	17.40	2.49	16.67	2.66	18.05
11	July 6	3.04	19.40	2.90	18.00	2.80	18.10	2.84	17.90	2.88	19.30
12	July 13	2.91	19.50	2.83	18.90	2.89	18.70	2.96	19.80	3.04	19.30
13	July 20	3.17	21.90	2.99	20.20	3.03	21.10	2.84	18.90	2.79	19.20
14	July 27	2.59	16.90	2.21	14.90	2.64	17.30	2.27	15.70	2.31	15.00
15	August 3	3.27	21.40	2.98	19.10	3.11	19.90	2.92	20.00	3.03	20.00
16	August 10	2.81	19.10	2.65	18.40	2.69	18.20	2.53	18.30	2.49	16.80
18	August 24	2.72	18.50	2.56	16.40	2.22	14.80	2.21	14.70	1.96	13.50
	Sum	45.35	314.29	45.23	303.83	43.23	302.19	44.24	310.96	44.48	309.42
	Average	2.84	19.64	2.83	18.99	2.70	18.89	2.77	19.44	2.78	19.34

SECOND FOOT.

1	April 29	2.82	17.31	2.83	16.79	2.80	19.36	2.97	17.65	3.15	18.72
3	May 11	2.95	17.36	2.92	18.04	2.68	16.15	2.56	15.35	2.45	14.25
5	May 25	2.86	16.92	2.74	16.33	2.72	16.18	2.79	16.34	2.72	16.48
7	June 8	2.46	15.80	2.58	15.30	3.28	20.00	3.25	23.00	4.47	30.50
9	June 22	2.65	16.70	2.47	14.83	2.36	14.24	2.52	14.46	2.30	13.37
11	July 6	3.02	17.20	2.39	15.00	2.79	16.00	2.62	16.20	2.88	16.10
13	July 20	2.95	18.30	2.88	18.10	2.79	16.60	2.72	16.70	2.73	15.40
15	August 3	2.56	14.90	2.44	14.90	2.52	15.30	2.69	16.00	2.44	13.90
18	August 24	3.87	26.20	2.11	12.20	2.01	11.40	1.95	13.50	2.28	13.50
	Sum	26.14	160.69	23.36	141.49	23.25	145.23	24.07	149.20	25.42	152.22
	Average	2.90	17.85	2.60	15.72	2.58	16.14	2.67	16.58	2.82	16.91

THIRD FOOT.

1	April 29	2.29	14.32	2.33	14.11	2.36	15.83	2.66	16.64	2.96	18.00
9	June 22	2.66	15.61	2.11	11.52	2.12	13.58	1.81	10.16	1.97	10.93
18	August 24	2.22	12.40	1.50	8.60	1.59	9.20	1.61	9.90	2.14	12.60
	Sum	7.17	42.33	5.94	34.23	6.07	38.61	6.08	36.70	7.07	41.53
	Average	2.39	14.11	1.98	11.41	2.02	12.87	2.03	12.23	2.36	13.84

FOURTH FOOT.

1	April 29	3.23	16.55	2.82	15.76	2.80	14.59	2.99	17.75	3.07	18.06
9	June 22	2.52	13.39	2.60	15.98	2.90	15.70	3.10	16.74	1.84	10.13
18	August 24	2.05	11.60	1.67	9.50	2.01	11.30	2.37	12.70	2.65	14.60
	Sum	7.80	41.54	7.09	41.24	7.71	41.59	8.46	47.19	7.56	42.79
	Average	2.60	13.85	2.36	13.75	2.57	13.86	2.82	15.73	2.52	14.26

Soil moisture in Janesville loam at Janesville, Wis., under fallow, with 5 grades of fertilization—1903.

FIRST FOOT.

Period.	Date.	Moisture in soil to which was added per acre— Nothing.		5 tons manure.		10 tons manure.		15 tons manure.		300 pounds guano.	
		Inches.	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*
1	April 29	3.22	30.27	3.63	30.73	3.40	31.89	3.00	31.07	3.27	29.25
3	May 11	2.94	27.13	2.07	28.00	3.42	28.69	3.41	28.22	3.14	26.63
4	May 18	2.86	25.00	3.14	26.00	3.07	25.48	3.22	26.79	2.97	24.76
5	May 25	3.19	27.34	3.40	25.97	2.74	21.40	2.94	24.72	3.00	22.29
6	June 1	3.56	29.10	3.18	27.80	3.59	28.90	3.48	30.50	3.20	31.10
7	June 8	3.46	25.00	3.25	26.20	3.30	25.90	3.42	26.90	3.51	25.10
8	June 15	3.33	25.49	3.41	24.38	3.38	23.90	3.22	24.96	3.11	24.37
9	June 22	3.19	25.58	3.42	25.65	3.52	26.06	3.63	26.99	3.57	26.05
10	June 29	3.20	24.34	3.07	21.88	3.30	24.64	2.89	25.88	3.41	27.88
11	July 6	4.52	33.70	3.98	28.40	3.88	20.20	4.04	30.20	4.06	30.10
12	July 13	3.80	29.20	3.51	27.20	3.63	28.40	3.60	29.10	3.74	29.40
13	July 20	3.76	30.10	3.99	30.20	3.65	28.20	3.76	28.60	3.83	27.90
14	July 27	4.01	29.70	4.19	31.80	3.55	25.20	3.56	24.80	3.45	27.20
15	August 3	3.50	26.50	3.51	24.80	3.45	24.70	3.55	26.30	3.69	27.30
16	August 10	3.38	27.30	3.48	26.70	3.71	26.60	3.80	27.50	3.51	27.60
18	August 25	3.41	24.00	3.36	23.50	3.53	25.20	3.38	23.90	3.43	24.50
	Sum	54.33	449.75	54.59	427.21	55.12	425.36	54.92	436.43	54.91	431.43
	Average	3.40	28.11	3.41	26.70	3.45	26.59	3.43	27.28	3.44	26.96

SECOND FOOT.

1	April 29	4.10	26.33	4.18	25.12	4.34	27.82	3.87	25.30	3.79	23.47
3	May 11	3.34	20.64	3.57	23.13	3.25	20.73	3.55	22.61	3.34	21.89
5	May 25	3.11	20.24	3.08	19.09	2.99	19.12	2.92	18.96	2.80	18.17
7	June 8	3.29	20.40	3.42	21.10	3.43	21.50	3.44	20.10	3.34	21.20
9	June 22	3.41	21.72	3.44	21.79	3.36	21.48	3.22	20.00	3.18	19.83
11	July 6	3.60	23.30	3.55	24.30	3.69	23.00	3.53	22.20	3.80	23.80
13	July 20	3.52	22.90	3.43	23.30	3.50	23.60	3.51	22.50	3.49	22.60
15	August 3	3.27	20.10	3.25	20.00	3.27	20.80	3.46	21.70	3.26	20.50
18	August 25	2.79	16.50	3.08	19.70	3.04	19.50	3.06	19.00	3.15	19.30
	Sum	30.43	192.13	31.00	197.53	30.87	197.55	30.56	192.37	30.15	190.76
	Average	3.38	21.35	3.44	21.95	3.43	21.95	3.40	21.37	3.35	21.20

THIRD FOOT.

1	April 29	4.42	27.25	4.28	27.95	4.12	25.57	4.19	25.45	4.26	25.38
9	June 22	3.99	23.13	3.44	20.31	3.67	21.47	3.65	20.87	3.59	21.01
18	August 25	3.58	20.10	3.51	20.60	3.45	19.30	3.61	21.00	3.02	18.00
	Sum	11.99	70.48	11.23	68.86	11.24	66.34	11.45	67.32	10.87	64.39
	Average	3.99	23.49	3.74	22.95	3.75	22.11	3.82	22.44	3.62	21.46

FOURTH FOOT.

1	April 29	5.35	30.04	5.52	30.59	3.86	20.83	4.95	28.48	4.97	28.34
9	June 22	4.33	24.32	4.43	24.63	4.51	24.08	4.63	24.85	4.41	24.39
18	August 25	4.40	23.50	4.37	23.00	4.20	21.00	4.58	23.70	4.28	23.50
	Sum	14.08	77.86	14.32	78.22	12.57	65.91	14.16	77.03	13.66	76.23
	Average	4.69	25.95	4.77	26.07	4.19	21.97	4.72	25.68	4.55	25.41

Soil moisture in Miami loam, at Janesville, Wis., under fallow, with 5 grades of fertilization—1903.

FIRST FOOT.

Period.	Date.	Moisture in soil to which was added per acre—									
		Nothing.		5 tons manure.		10 tons manure.		15 tons manure.		300 pounds guano.	
		Inches.	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*
1	April 29	2.05	17.94	2.24	19.21	1.98	18.44	2.24	20.55	2.30	19.32
3	May 11	2.44	17.69	2.30	18.62	2.49	19.25	2.34	18.53	2.34	18.09
4	May 18	2.29	16.50	2.26	16.28	2.24	16.48	2.50	17.38	2.18	15.94
5	May 25	3.14	24.10	2.94	25.00	2.64	23.60	2.94	23.80	2.70	22.80
6	June 1	2.96	21.40	2.39	16.90	2.81	21.40	2.92	22.20	2.95	21.70
7	June 8	2.91	20.70	2.87	18.70	2.88	19.00	2.96	18.80	2.91	20.80
8	June 15	2.70	17.34	2.73	19.08	2.65	17.01	3.38	21.94	2.68	16.98
9	June 22	2.81	18.32	2.64	16.81	2.59	16.48	2.88	20.16	3.45	22.37
10	June 29	2.81	17.39	2.76	17.20	2.62	16.17	2.59	18.00	2.60	16.04
11	July 6	2.33	15.20	2.37	14.90	2.37	14.50	2.61	16.50	2.84	18.60
12	July 13	2.80	18.60	2.75	17.60	2.82	18.00	2.76	17.30	2.90	19.50
13	July 20	2.84	18.00	2.54	16.00	2.73	17.00	3.08	20.30	2.83	18.30
14	July 27	2.46	15.80	2.31	14.70	2.30	14.20	2.20	13.90	2.26	14.20
15	August 3	3.63	22.20	3.45	21.70	3.58	22.80	3.66	23.40	3.45	22.00
16	August 10	2.54	16.40	2.74	18.00	2.56	16.10	2.44	15.50	2.53	16.40
18	August 25	2.75	17.30	2.56	17.30	2.68	17.50	3.14	21.00	3.25	21.20
	Sum	43.46	294.88	41.55	288.00	41.94	289.93	44.64	309.26	44.17	304.54
	Average	2.72	18.43	2.60	18.00	2.67	18.12	2.79	19.33	2.76	19.04

SECOND FOOT.

1	April 29	2.91	16.81	2.91	18.99	2.59	15.25	2.76	16.44	2.67	17.58
3	May 11	2.96	16.42	2.45	14.28	2.66	14.84	2.40	14.58	2.89	16.48
5	May 25	2.67	15.80	2.45	17.50	2.28	14.40	2.52	15.60	2.28	13.80
7	June 8	3.11	17.50	2.49	16.80	2.36	16.10	2.49	14.70	2.54	15.50
9	June 22	2.76	15.64	2.42	14.48	2.87	17.35	2.80	16.20	2.76	16.05
11	July 6	2.39	15.40	2.27	13.40	2.59	14.20	2.35	13.70	2.43	14.20
13	July 20	2.60	17.20	2.90	16.90	2.50	14.00	2.42	13.90	2.74	15.50
15	August 3	2.72	16.00	2.72	16.80	2.82	16.60	2.88	17.20	2.91	18.30
18	August 25	2.42	14.00	2.31	15.30	2.38	14.80	2.30	13.00	2.23	13.00
	Sum	24.54	144.77	22.92	145.45	23.05	137.54	22.92	135.32	23.45	140.41
	Average	2.73	16.09	2.55	16.16	2.56	15.28	2.55	15.04	2.61	15.60

THIRD FOOT.

1	April 29	2.45	14.11	2.31	15.12	2.36	16.80	2.42	13.89	2.89	15.67
9	June 22	2.47	13.87	1.91	11.49	2.44	13.56	2.70	14.37	2.42	13.22
18	August 25	2.24	12.20	2.30	12.80	2.35	14.70	2.30	13.50	1.98	12.60
	Sum	7.16	40.18	6.52	39.41	7.15	45.06	7.42	41.76	7.29	41.49
	Average	2.39	13.39	2.17	13.14	2.38	15.02	2.47	13.92	2.43	13.83

FOURTH FOOT.

1	April 29	2.00	13.18	2.16	12.49	2.84	14.85	2.00	11.62	2.56	15.28
9	June 22	2.31	12.52	1.96	10.24	2.24	12.04	2.07	11.65	2.14	11.88
18	August 25	2.19	12.30	1.86	10.50	2.58	13.50	2.83	14.00	2.33	13.00
	Sum	6.50	38.00	5.98	33.23	7.66	40.39	6.90	37.27	7.03	40.16
	Average	2.17	12.67	1.99	11.08	2.55	13.46	2.30	12.42	2.34	13.39

Soil moisture in Janesville loam, at Janesville, Wis., under potatoes, with 5 grades of fertilization—1903.

FIRST FOOT.

Period.	Date.	Moisture in soil to which was added per acre—									
		Nothing.		5 tons manure.		10 tons manure.		15 tons manure.		300 pounds guano.	
		Inches.	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*
1	April 29	3.03	27.92	2.74	28.30	3.33	28.90	2.65	29.45	2.89	28.36
3	May 11	2.94	25.79	3.40	26.99	3.07	27.02	3.22	27.06	2.79	25.80
4	May 18	2.76	24.59	2.60	23.20	2.79	24.74	2.90	25.51	2.97	24.76
5	May 25	2.99	24.71	3.35	25.93	3.13	25.14	2.94	25.05	2.88	23.43
6	June 1	3.57	30.40	2.98	29.20	3.14	30.10	3.22	31.70	3.51	32.80
7	June 8	3.52	27.00	3.30	24.60	3.48	25.70	3.22	24.00	3.37	26.50
8	June 15	3.45	25.32	3.20	24.34	3.52	26.27	3.38	26.58	3.33	25.04
9	June 22	3.33	24.96	3.40	25.52	3.36	25.02	3.42	25.98	2.64	19.32
10	June 29	2.72	21.71	2.65	21.39	2.72	21.75	2.95	22.46	3.03	23.55
11	July 6	2.91	23.60	3.53	27.80	3.49	27.00	3.60	26.90	4.03	30.90
12	July 13	3.81	28.60	3.73	29.20	3.81	28.80	3.44	27.70	3.71	28.80
13	July 20	3.48	28.20	3.58	27.40	3.79	27.10	3.65	28.90	3.68	28.20
14	July 27	2.87	22.30	3.23	24.30	3.45	26.10	3.38	24.60	3.42	25.90
15	August 3	3.51	28.60	3.48	27.90	3.96	29.60	3.84	28.40	3.83	29.60
16	August 10	3.08	25.30	3.11	25.00	3.27	26.80	3.37	28.40	3.45	29.60
18	August 25	3.34	26.20	3.31	26.00	2.88	21.40	2.94	22.80	3.34	25.00
	Sum	51.31	415.20	50.59	417.07	53.19	421.44	52.12	425..09	52.87	427.56
	Average	3.21	25.95	3.16	26.07	3.32	26.34	3.26	26.57	3.31	26.72

SECOND FOOT.

1	April 29	3.76	23.97	3.18	24.02	3.48	25.31	3.84	24.26	3.81	23.83
3	May 11	3.29	21.44	3.37	21.67	3.43	22.47	3.36	22.15	3.44	21.78
5	May 25	3.00	19.22	2.65	16.90	3.14	19.87	3.07	18.73	2.80	18.96
7	June 8	3.25	20.30	3.29	21.40	3.49	21.30	3.00	18.10	3.34	20.80
9	June 22	2.88	18.10	3.34	20.71	3.07	19.89	2.98	19.06	3.19	20.34
11	July 6	3.43	21.80	3.03	19.40	3.35	20.40	3.49	22.40	3.92	25.20
13	July 20	3.72	25.20	3.48	22.40	3.49	22.20	3.68	23.90	3.73	23.30
15	August 3	3.28	20.70	2.89	18.70	3.04	19.90	2.96	19.40	3.21	20.40
18	August 25	3.34	22.00	3.22	19.80	2.91	17.30	3.11	17.80	2.99	20.00
	Sum	29.95	192.73	28.45	184.00	29.50	188.64	29.49	185.80	30.43	194.61
	Average	3.33	21.41	3.16	20.44	3.28	20.96	3.28	20.64	3.38	21.62

THIRD FOOT.

1	April 29	4.04	24.06	3.75	23.20	3.86	22.68	4.11	24.37	3.95	24.41
9	June 22	3.78	22.92	3.11	18.99	3.17	18.25	3.44	22.21	3.29	19.79
18	August 25	2.59	22.50	3.34	20.70	3.36	20.10	3.11	21.50	3.50	21.50
	Sum	10.41	69.48	10.20	62.89	10.39	61.03	10.66	68.08	10.74	65.70
	Average	3.47	23.16	3.40	20.96	3.46	20.34	3.55	22.69	3.58	21.90

FOURTH FOOT.

1	April 29	4.65	25.81	4.75	26.34	4.47	25.33	4.57	25.16	4.71	26.47
9	June 22	4.47	25.56	3.84	21.18	3.49	18.95	4.55	24.38	4.32	24.51
18	August 25	4.49	24.70	3.74	19.50	4.24	24.00	3.72	20.20	4.03	21.80
	Sum	13.61	76.07	12.33	67.02	12.20	68.28	12.84	69.74	13.06	72.78
	Average	4.54	25.36	4.11	22.34	4.07	22.76	4.28	23.25	4.35	24.26

Soil moisture in Miami loam at Janesville, Wis., under potatoes, with 5 grades of fertilization—1903.

FIRST FOOT.

Period.	Date.	Moisture in soil to which was added per acre—									
		Nothing.		5 tons manure.		10 tons manure.		15 tons manure.		300 pounds guano.	
		Inches.	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*	*Inches.*	*Per ct.*
1	April 29..........	2.58	22.27	2.82	22.07	2.34	21.60	2.91	21.96	2.69	21.12
3	May 11..........	2.54	18.91	2.64	21.44	2.70	20.53	2.70	19.89	2.66	18.82
4	May 18..........	2.58	19.13	2.82	19.36	2.59	19.40	2.40	19.40	2.29	17.57
5	May 25..........	3.50	26.59	3.55	25.60	3.36	25.50	3.17	25.76	3.19	24.23
6	June 1..........	3.11	23.00	3.15	22.70	3.03	22.90	3.92	30.70	3.11	22.40
7	June 8..........	2.91	20.00	2.70	20.70	2.81	19.80	2.58	19.90	2.86	20.20
8	June 15..........	2.67	17.78	2.72	18.35	2.64	17.59	2.62	17.74	2.51	16.22
9	June 22..........	2.50	16.77	2.64	17.22	2.53	16.79	2.47	16.04	2.44	15.82
10	June 29..........	2.59	17.31	2.44	16.21	2.36	15.95	2.01	13.62	2.19	14.56
11	July 6..........	2.37	15.90	2.91	12.20	2.42	17.20	2.23	14.80	1.84	12.60
12	July 13..........	3.19	20.50	2.77	18.30	2.79	18.00	2.88	18.50	2.97	19.60
13	July 20..........	2.68	18.20	2.77	18.70	2.69	17.90	2.68	18.10	3.06	20.20
14	July 27..........	2.36	15.70	2.59	17.80	2.34	15.90	2.07	13.70	1.89	12.40
15	August 3..........	3.27	22.40	3.07	20.60	3.03	20.00	2.88	18.30	3.29	21.70
16	August 10..........	2.67	19.40	2.86	19.60	2.92	20.30	2.72	18.60	2.65	18.60
18	August 25..........	3.11	20.80	3.34	24.70	3.26	22.00	2.99	20.70	3.20	21.00
	Sum.....	44.63	314.66	45.79	326.55	43.81	311.36	43.23	307.71	42.84	297.04
	Average.	2.79	19.67	2.86	20.41	2.74	19.46	2.70	19.23	2.68	18.57

SECOND FOOT.

1	April 29..........	3.27	21.43	3.19	20.15	2.94	18.05	2.72	18.85	3.06	19.16
3	May 11..........	3.03	19.27	3.08	18.97	2.90	17.71	2.60	15.98	2.83	17.47
5	May 25..........	3.38	20.40	3.52	21.00	3.05	19.00	3.20	19.10	2.77	17.90
7	June 8..........	2.96	18.50	3.03	17.80	2.43	14.80	2.04	12.20	2.79	16.70
9	June 22..........	2.44	14.53	2.47	15.68	2.09	14.44	2.49	14.23	2.01	11.22
11	July 6..........	2.54	16.70	2.03	13.10	2.54	15.00	2.20	13.10	2.58	15.20
13	July 20..........	2.68	17.50	2.86	17.10	2.57	15.40	2.57	15.20	2.54	14.70
15	August 3..........	2.86	19.70	2.54	15.60	2.33	13.70	2.33	14.70	2.62	15.90
18	August 25..........	2.65	16.00	2.76	16.50	2.76	15.80	2.23	13.30	2.18	12.50
	Sum.....	25.81	164.03	25.48	155.90	23.61	143.90	22.38	136.66	23.38	140.75
	Average.	2.87	18.23	2.83	17.32	2.62	15.99	2.49	15.18	2.60	15.64

THIRD FOOT.

1	April 29..........	2.72	16.80	2.47	15.99	2.49	12.97	2.72	15.65	2.64	16.58
9	June 22..........	1.70	10.24	2.36	12.81	2.16	10.87	2.15	12.32	1.60	9.59
18	August 25..........	2.07	12.30	2.19	12.80	1.93	10.50	2.27	12.90	1.68	10.40
	Sum.....	6.49	39.34	7.02	41.60	6.58	34.34	7.14	40.87	5.92	36.57
	Average.	2.16	13.11	2.34	13.87	2.19	11.45	2.38	13.62	1.97	12.19

FOURTH FOOT.

1	April 29..........	2.26	15.65	2.33	12.31	2.28	12.62	2.70	14.35	2.34	13.58
9	June 22..........	1.84	10.09	1.98	11.43	1.70	9.93	2.73	15.24	2.15	13.36
18	August 25..........	1.78	12.10	1.70	10.20	1.84	10.30	2.14	11.50	2.12	11.30
	Sum.....	5.88	37.74	6.01	33.94	5.82	32.85	7.57	41.09	6.61	38.24
	Average.	1.96	12.58	2.00	11.31	1.94	10.95	2.52	13.70	2.20	12.75

RELATIVE RATES OF EVAPORATION AT STATIONS IN FOUR STATES FROM SOIL SURFACES SATURATED BY CAPILLARITY, AND FROM CORN.

In connection with the comparative studies regarding the amounts of water-soluble salts which could be recovered from soils of different types and their relation to the yields of crops growing upon the soils, a study was also made of the rates of evaporation during the growing season at the 4 stations, both from saturated soil surfaces and from growing plants.

Rates of Evaporation from Soil Surfaces Saturated by Capillarity.

In order to make a comparative study of the rate of evaporation from continuously moist soil surfaces a soil evaporimeter (Pl. II, fig. 1) was constructed from galvanized iron in the form of a cylinder, with closed bottom, 2 feet deep, which was sunk in the field. The general surroundings of the two evaporimeters are shown in Pl. II (fig. 2) which represents the pair of instruments at Lancaster, Pa. This cylinder had a diameter of 4 feet and was arranged in such a way that an automatic record of the rate of evaporation might be obtained by the use of a water register, which was located in the shelter shown in the illustration.

The evaporimeters for the 4 stations were made in exactly the same manner, with like dimensions, and were similarly placed. They were all filled with soil from the unfertilized subplots, using soil from the surface 9 inches. The soil was introduced in layers about 2 inches thick and firmed so as to secure about the normal weight per cubic foot for the soil in place.

At the bottom of the evaporimeter there was a water reservoir, rising to the height of 1 foot, upon which the shelter for the water register rested. Water could be added to or removed from the reservoir as desired. Upon this water surface rested the float of the water register. Before introducing the soil the bottom of the evaporimeter was covered with a layer of sand or gravel, thus providing a medium through which the water could spread easily and uniformly under the whole soil surface. The level of the surface of the soil in the evaporimeter was about 2 inches below that of the rim, and was left firm, smooth, and horizontal, and was kept free from all plant growth throughout the season. The level of the water in the reservoir was usually maintained at about 1 foot below the surface, water being added once per week and removed when made necessary as the result of rains. It was hoped by means of the water registers to secure a record of the variations in the rate of evaporation during different times of the day, but unfortunately the registers were not sufficiently delicate in their construction to allow satisfactory curves to be recorded from which the diurnal variations in the rates of evaporation could be accurately determined.

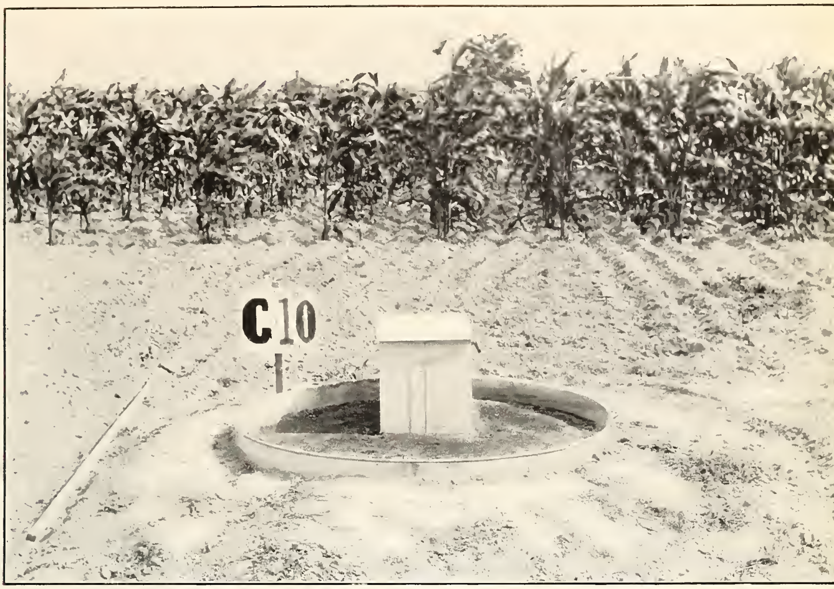


FIG. 1.—SOIL EVAPORIMETER 4 FEET IN DIAMETER AND 2 FEET DEEP, WITH WATER REGISTER IN CHAMBER AT BOTTOM UNDER BOX SHELTER.

FIG. 2.—LOCATION AND SURROUNDINGS OF EVAPORIMETERS, LANCASTER, PA.

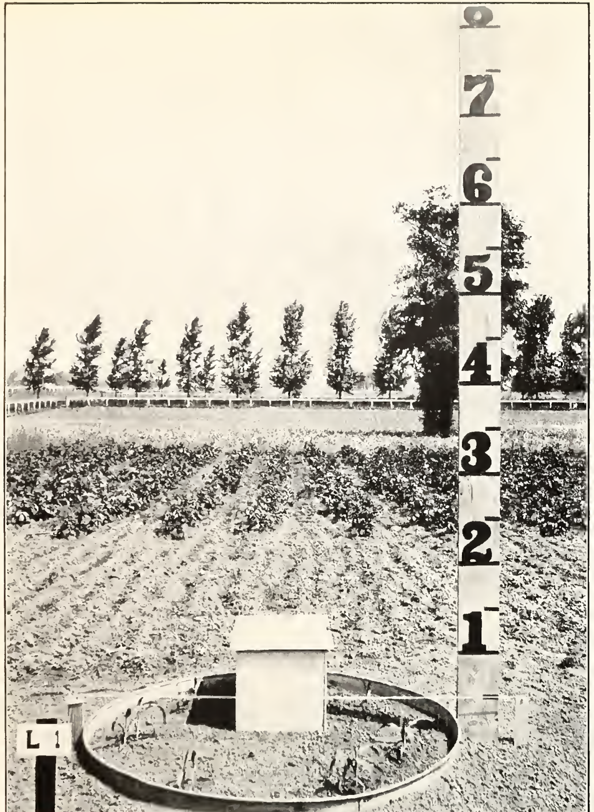


FIG. 1.—PLANT EVAPORIMETER AT EARLY STAGE, PLANTS THINNED TO TWO STALKS IN THE HILL.

FIG. 2.—PLANT EVAPORIMETER, PLANTS NEARLY FULL GROWN.

The total rainfall area of the evaporimeter was 12.5664 square feet and the evaporation surface, deducting the area occupied by the instrument shelter, was 11.0664 square feet. The instrument shelter was placed on the north side of the evaporimeter where a minimum of shadow would be cast on the evaporating surface of the soil. In the following table are given the amounts of evaporation which took place from the several evaporimeters:

Total and mean rates of evaporation from continuously moist soil surfaces.

Evaporation.	Goldsboro, N. C., Norfolk sandy soil.	Upper Marlboro, Md., Norfolk sand.	Lancaster, Pa., Hagerstown clay loam.	Janesville, Wis., Janesville loam.
Total for season, inches	23.92	27.27	21.74	25.26
Mean per day, inches	.212	.192	.153	.180
Mean per day, pounds per square foot	1.1	.98	.796	.938

From the data of the table it is seen that the highest rate of evaporation occurred where the highest temperature records were obtained. The rate at Upper Marlboro also stood second, as was the case with the temperature; but at Lancaster there was a lower rate of evaporation than the records showed for Janesville, where the temperature was a little more than 3 degrees lower than at Lancaster.

Rates of Evaporation from Ten Corn Plants.

A set of evaporimeters, similar in construction to the soil evaporimeters described in the last section, and having the same dimensions except that they were 4 feet deep instead of 2, were provided, there being one for each of the 4 stations. These were filled with the same types of soil used in the soil evaporimeters, and also to within 2 inches of the rim. In the bottom of the plant evaporimeter there was a larger reservoir for holding water, extending nearly across the cylinder, and upon this the shelter for the water register rested, this being also placed on the north side of the cylinder, where it would cast a minimum of shadow on the soil surface. The instrument at each station stood in the strip of fallow ground which separated the corn from the potatoes.

In each plant evaporimeter there were planted 5 hills of corn, using the same seed in each case, namely, Iowa Goldmine. After the plants had become well established, the hills were thinned to two stalks in each, as shown in Pl. III (fig. 1). It had been the intention to have the corn planted in these evaporimeters on the same date as was done in the field, but conditions could not be so controlled as to make this possible and the evaporimeter at Goldsboro was planted on May 22; that at Marlboro, May 26; the one at Lancaster, June 6; and the one at Janesville, June 9. In Pl. III (fig. 2) is shown one of the plant evaporimeters at a later stage in the growth of the corn.

A larger number of plants was grown upon the evaporimeters than is allowed for similar areas in field practice. This large number was chosen for the following reasons: (1) Because it was desired to make the evaporation as great as practicable; (2) because, the water level being maintained continuously at within 36 to 42 inches of the surface, and all the soil being taken from the surface 9 inches, a closer stand upon the ground was perfectly permissible; and (3) because, on account of the plants standing in the open and not surrounded by other plants, there was no shading which would bring injury to the plants.

The amounts of evaporation which occurred at the several stations are given in the table which follows:

Evaporation from 10 corn plants during the growing season and from the soil surfaces upon which they grew—1903.

Items.	Goldsboro, N. C.	Upper Marlboro, Md.	Lancaster, Pa.	Janesville, Wis.
Total water evaporated, inches	25.07	20.23	24.49	26.81
Number of days of growth	97	126	128	126
Mean evaporation per day, inches	0.259	0.161	0.191	0.213
Yield, dry matter per acre, pounds	17,319	4,510	12,967	20,750
Pounds water per pound of dry matter	387.4	1,152	474	336.4

In these cases the mean daily rate of evaporation at Goldsboro was greatest, and it was larger at Janesville than at Lancaster, these relations being the same as in case of the soil evaporimeters.

Comparing the evaporation from the plant evaporimeters with that from the soil evaporimeters, it will be seen that the rate of loss of water from the former has exceeded that from the continuously moist soil in 3 out of the 4 cases. Taking the rate of evaporation from the soil evaporimeters as 100 per cent, that from the plant evaporimeters was 122.1 per cent at Goldsboro, 83.6 per cent at Upper Marlboro, 124.8 per cent at Lancaster, and 118.3 per cent at Janesville.

The lack of vigorous growth on the Norfolk sand, indicated by the small amount of dry matter produced, is at once the cause of the large amount of water evaporated per pound of dry matter produced and the relatively small evaporation during the growing season. It will be observed that, in proportion to the dry matter produced, the loss of water from the plant evaporimeter containing the Norfolk sand was nearly three times the mean loss from the other three. This relation is partly due to the high rate of evaporation from the soil itself; but in the long series of studies made by the writer on the amounts of water required for a pound of dry matter, it was found true, almost without exception, that strong vigorous growth and high yields of dry matter are always associated with a small transpiration of water when measured by the dry matter produced.

Changes in Water-Soluble Salt Content of the Soil in the Plant Evaporimeters.

One purpose in growing a large number of plants on each of the plant evaporimeters and in using the unfertilized soils, was, if possi-

ble, to tax to their limits the productive capacities of the several soils under treatment, expecting that by so doing the relative amounts of dry matter produced might be an expression of the immediate productive capacities of the several soils.

It must be understood that in filling the cylinders with soil from the surface 9 inches there was practically placed at the disposal of the plants a much deeper surface soil than would be available to the crops in the field, the arrangements which were adopted practically giving to the plants at least a full 2½ feet of true surface soil in which the root system could be developed.

A composite sample of each soil as it was put into the evaporimeter was taken for examination for water-soluble salts carried by the soils at the beginning of the season. At the close of the season another set of samples was taken and these were examined for water-soluble salts, the object being to ascertain whether, in the growing of these heavy crops of corn upon a definitely circumscribed volume of soil, there would result a measurable change in the amounts of water-soluble salts which could be recovered. In the table which follows are given the results of the determinations made on the surface 3 feet of soil for each of the evaporimeters; and in the same table are also given the observed amounts present in the several soils at the beginning of the experiment.

Amounts of water-soluble salts recovered by 3-minute washings of the soils in the 4 plant evaporimeters at the start and at the close of the growing season—1903.

[In parts per million of dry soil.]

Soil.	K.	Ca.	Mg.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_2.
Norfolk sandy soil:									
First foot	1.84	27.0	8.15	3.13	2.73	72.5	6.0	0	4.1
Second foot	2.38	10.5	7.96	2.42	3.00	36.0	6.0	0	3.9
Third foot	5.68	12.7	7.96	2.27	2.70	35.0	6.0	0	4.2
Average	3.30	17.4	8.02	2.61	2.81	47.8	6.0	0	4.07
In composite at start	5.61	25.5	10.70	20.46	2.85	45.5	17.0	0	4.05
Difference	−2.31	− 8.1	−2.68	−17.85	−0.04	+ 2.3	−23.0	0	+0.02
Norfolk sand:									
First foot	2.38	41.3	9.51	6.26	3.80	77.5	14.0	0	4.7
Second foot	4.52	70.0	10.36	13.96	3.80	127.5	14.0	0	4.7
Third foot	3.94	50.0	10.70	6.05	3.90	110.0	30.0	0	4.8
Average	3.61	53.77	10.19	8.76	3.83	105.0	19.33	0	4.73
In composite at start	5.20	22.25	11.95	16.52	2.95	35.5	7.00	0	6.45
Difference	−1.59	+ 31.52	−1.76	− 7.76	+ .88	+69.5	+12.33	0	−1.72
Hagerstown clay loam:									
First foot	6.68	243.8	32.36	26.92	12.90	256.3	124.0	0	15.1
Second foot	6.18	250.0	32.36	66.00	13.80	275.0	112.0	0	15.3
Third foot	6.10	200.0	31.71	103.80	13.20	200.0	112.0	0	13.6
Average	6.32	231.27	32.14	65.57	13.30	243.8	116.0	0	14.7
In composite at start	12.10	281.25	28.54	50.80	14.10	207.5	88.0	0	15.8
Difference	−5.78	− 49.98	+3.60	+14.77	− .80	+36.3	+28.0	0	− 1.1
Janesville loam:									
First foot	3.94	100.0	19.02	22.15	17.1	105.0	52.0	0	18.6
Second foot	3.87	137.5	19.56	30.25	17.3	160.0	56.0	0	19.8
Third foot	3.91	105.0	29.78	12.98	19.3	90.0	80.0	0	21.5
Average	3.91	114.17	22.79	21.79	17.9	118.3	62.67	0	19.97
In composite at start	6.92	215.65	24.11	68.55	19.7	150.0	46.00	0	23.55
Difference	−3.01	−101.53	−1.32	−46.76	−1.8	−31.7	+16.67	0	−3.58

From the data of the preceding table there has been computed the change which the analyses indicate as having occurred in the water-soluble salts recovered by the 3-minute washings from the upper 3 feet of soil in the plant evaporimeters, using the amounts found in the composites at the start as the basis upon which to compute the changes. The results so computed are given in the next table:

Amounts of water-soluble salts recovered by 3-minute washings of the soils in the surface 3 feet of the plant evaporimeters at the beginning and close of the experiment, and the change.

[In parts per million of dry soil.]

NORFOLK SANDY SOIL.

Depth.	K.	Ca.	Mg.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_2.
First foot:									
At start	5.61	25.5	10.70	20.46	2.85	45.5	− 17.0	0	4.05
At close	1.84	27.0	8.15	3.13	2.73	72.5	6.0	0	4.10
Change	− 3.77	+ 1.5	− 2.55	−17.33	− 0.12	+ 27.0	+ 23.0	0	+ 0.05
Second foot:									
At start	5.61	25.5	10.70	20.46	2.85	45.5	− 17.0	0	4.05
At close	2.38	10.5	7.96	2.42	3.00	36.0	6.0	0	3.90
Change	− 3.23	− 15.0	− 2.74	−18.04	+ 0.15	− 9.5	+ 23.0	0	− 0.15
Third foot:									
At start	5.61	25.5	10.70	20.46	2.85	45.5	− 17.0	0	4.05
At close	5.68	12.7	7.96	2.27	2.70	35.0	6.0	0	4.20
Change	+ 0.07	− 12.8	− 2.74	−18.19	− 0.15	− 10.5	+ 23.0	0	+ 0.15

NORFOLK SAND.

Depth.	K.	Ca.	Mg.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_2.
First foot:									
At start	5.20	22.25	11.90	19.52	2.95	35.5	7.0	0	6.45
At close	2.38	41.30	9.51	6.26	3.80	77.5	14.0	0	4.70
Change	− 2.82	+ 19.05	− 2.39	−13.26	+ 0.85	+ 42.0	+ 7.0	0	− 1.75
Second foot:									
At start	5.20	22.25	11.90	19.52	2.95	35.5	7.0	0	6.45
At close	4.52	70.00	10.36	13.96	3.80	127.5	14.0	0	4.70
Change	− 0.68	+ 47.75	− 1.54	− 5.56	+ 0.85	+ 92.0	+ 7.0	0	− 1.75
Third foot:									
At start	5.20	22.25	11.90	16.52	2.95	35.5	7.0	0	6.45
At close	3.94	50.00	10.70	6.05	3.90	110.0	30.0	0	4.80
Change	− 1.26	+ 27.75	− 1.20	−10.47	+ 0.95	+ 74.5	+ 23.0	0	− 1.65

HAGERSTOWN CLAY LOAM.

Depth.	K.	Ca.	Mg.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_2.
First foot:									
At start	12.10	281.21	28.54	50.80	14.1	207.5	88.0	0	15.80
At close	6.68	243.80	32.36	26.92	12.9	256.3	124.0	0	15.10
Change	− 5.42	− 37.41	+ 3.82	−23.88	− 1.2	+ 48.8	+ 36.0	0	− 0.70
Second foot:									
At start	12.10	281.21	28.54	50.80	14.1	207.5	88.0	0	15.80
At close	6.18	250.00	32.36	66.00	13.8	275.0	112.0	0	15.30
Change	− 5.92	− 31.21	+ 3.82	+15.20	− 0.3	+ 67.5	+ 24.0	0	− 0.50
Third foot:									
At start	12.10	281.21	28.54	50.80	14.1	207.5	88.0	0	15.80
At close	6.10	200.00	31.71	103.80	13.2	200.0	112.0	0	13.60
Change	− 6.00	+ 81.21	+ 3.17	+53.00	− 0.9	− 7.5	+ 24.0	0	− 2.20

Amounts of water-soluble salts recovered by 3-minute washings of the soils in the surface 3 feet of the plant evaporimeters at the beginning and close of the experiment, and the change—Continued.

JANESVILLE LOAM.

Depth.	K.	Ca.	Mg.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_2.
First foot:									
At start	6.92	215.65	24.11	68.55	19.7	150.0	46.0	0	23.55
At close	3.94	100.00	19.02	22.15	17.1	105.0	52.0	0	18.60
Change	− 2.98	−115.65	− 5.09	− 46.40	− 2.6	− 45.0	+ 6.0	0	− 4.95
Second foot:									
At start	6.92	215.65	24.11	68.55	19.7	150.0	46.0	0	23.55
At close	3.87	137.50	19.56	30.25	17.3	160.0	56.0	0	19.80
Change	− 3.05	− 78.15	− 4.55	−38.30	− 2.4	+ 10.0	+ 10.0	0	− 3.75
Third foot:									
At start	6.92	215.65	24.11	68.55	19.7	150.0	46.0	0	23.55
At close	3.91	103.00	29.78	12.98	19.3	90.0	80.0	0	21.50
Change	− 3.01	−112.65	+ 5.67	−55.57	− 0.4	− 60.0	+ 34.0	0	− 2.05

It should be said regarding the computed changes for this table that the composite samples of soil taken in the spring were held in the dry condition until fall before they were examined, and on this account, in accord with some other observations which have been made, the change which actually occurred was probably larger, rather than smaller, than the figures indicate.

The absolute amounts of change which have occurred in the upper 3 feet of the Goldsboro and Janesville evaporimeters, expressed in pounds per acre in the respective feet, are given in the next table. The omission of the results for the other 2 evaporimeters from this table is on account of the fact that in neither case did there occur a perfectly normal development of plants. The frequent and rather heavy rainfalls at Lancaster, together with the closeness of the texture of the soil, apparently kept all but the upper foot of soil in too moist a condition for the best growth, the yield being less than at Goldsboro. The normal conditions of the field are certainly the reverse of those shown. The small yield on the Norfolk sand is unexplained by any observed conditions, unless it be that the unfertilized soil under the close stand was incapable of producing normal growth. To make the necessary computations for the values in this table the dry weights of a cubic foot of the respective soils has been computed from the observed pore space in the soil of the evaporimeters, using the specific gravity 2.65 for the soil and a weight of 62.42 pounds for a cubic foot of water. The Norfolk sandy soil was found to weigh 88.94 pounds per cubic foot, the Norfolk sand 83.08 pounds, the Hagerstown clay loam 72.22 pounds, and the Janesville loam 70.78 pounds per cubic foot.

Indicated changes in the water-soluble salts in the first, second, and third feet of soil in the plant evaporimeters at Goldsboro and Janesville—1903.

[In pounds per acre-foot.]

	K.	Ca.	Mg.	NO_3.	HPO_4.	SO_4.	HCO_3.	SiO_2.
Norfolk sandy soil:								
First foot	−14.60	+ 5.81	− 9.88	− 67.14	− 0.46	+104.60	+ 89.10	+ 0.19
Second foot	−12.51	− 58.11	−10.61	− 69.89	+ 0.58	− 36.80	+ 89.10	− 0.58
Third foot	+ 0.27	− 49.59	−10.61	− 70.40	− 0.58	− 40.68	+ 89.10	− 0.58
Total	−26.84	−101.89	−31.10	−207.43	− 0.46	+ 27.12	+267.30	− 0.97
Janesville loam:								
First foot	− 9.19	−356.70	−15.69	−143.05	− 8.01	−138.70	+ 18.49	−15.26
Second foot	− 9.40	−240.90	−14.09	−118.10	− 7.40	+ 30.83	+ 30.83	−11.56
Third foot	− 9.28	−347.40	+17.48	−167.40	− 1.23	−184.90	+104.90	− 3.24
Total	−27.87	−945.00	−12.30	−428.55	−16.64	−292.77	+154.22	−30.06

From this table it appears that, in the two evaporimeters upon which the crops developed normally, there was a total reduction in potash of 26.84 pounds per acre in the surface 3 feet of the Norfolk sandy soil, and 27.87 pounds per acre in the Janesville loam. There were very large reductions in the amounts of nitric acid and of lime, indeed, of each of the ingredients except HCO_3 in the case of the Janesville loam; and except in the cases of phosphoric acid, sulphuric acid, and HCO_3 in the Norfolk sandy soil.

COMPARATIVE SOIL-MOISTURE STUDIES ON EIGHT SOIL TYPES.

It is a matter of general experience that in partially arid climates where the rain falls, as it does in California, chiefly during the winter and early spring, and where there is no effective rainfall during the growing season, unexpectedly large yields are often secured by "dry farming" as the result of the soil moisture carried by the soil at the time the crop is planted; while in humid climates, where rain falls periodically during the growing season, crops almost invariably suffer when there is an interval of drought exceeding ten or fifteen days. The observations here presented were made to ascertain in how far the soil moisture contained in the soil at the beginning of the growing season is capable of carrying a corn crop toward maturity when no rain is allowed to fall upon the ground, and what the yields would be.

Description of the Method.

In order to bring the observations under as nearly field conditions as possible, 2 blocks of soil on each of the 2 soil types at each of the 4 stations were cut off from the adjacent soil of the field by digging trenches around them to a depth of 4 feet and encasing these blocks in a framework of lath so as to shut them off from a supply of moisture through lateral capillary movement from the adjacent soil, and in one block in each set the cube was cut off from a capillary supply of water

from below by a similar provision. After the blocks had been thus incased the soil was returned to the trenches about them, and corn was planted on the blocks in the soil in its natural field condition holding the moisture which had been acquired during the rains which had preceded the beginning of the experiment.

The blocks were 4 feet on a side and the depth of the casings was 4 feet. One hill of corn was planted in the center of each of these cubes, the hills standing in the appropriate place for a regular hill of corn in the field in which the blocks stood, as shown in Pl. IV. To prevent surface water, in time of heavy rains, reaching the blocks their margins were protected by pieces of board set on edge, forming a frame which would prevent any water reaching the surface of the soil by flooding. Rainfall was excluded through the agency of a pyramidal tent 10 feet in height and 5 feet on a side at the base, carried by a single tent pole of gas pipe set just to the north side of the hill of corn. During pleasant weather the tent was always furled closely about the tent pole, as shown in the illustrations, but when it was likely to rain and during rainy days the tent was unfurled and staked so that its margin came within 6 inches of the ground and outside of the wooden guard. In this manner all rainfall was excluded from the areas.

The method of preventing access of water, through capillary movement, was as follows: The latticework was constructed by nailing together 4 pairs of lath, with the faces coming together, previously coated with asphalt paint. Using these 4 lath as uprights, other lath were nailed across them on both sides, leaving intervals between them of one-eighth of an inch, the lath being so placed that those on one side broke joints with those on opposite sides. The 4 guards, thus constructed, were set up against the cubes on the 4 sides. On top of the 4 guards was nailed a lath, so as to prevent soil from dropping down into the air space formed by the latticework. The height of these guards was such that the closed upper ends were about 3 inches below the surface of the cubes, a soil covering being provided, so that excessive aeration should not occur from the open spaces about the cubes formed by the lattice guards. The latticework thus cut off capillary connection between the soil on the inside and that on the outside, but allowed good aeration.

In the case of the 4 cubes whose bottoms were protected in order to prevent capillary rise from below, the method of procedure was to use the soil tube to cut a horizontal hole through the bottom of the block of soil, and then to drive a pair of lath with their contact faces first coated with asphalt and then nailed together, entirely through the hole formed by the soil tube. When this set of lath was in place, a second channel was prepared into which other lath were similarly forced by driving, repeating this operation until the entire cube of soil had its

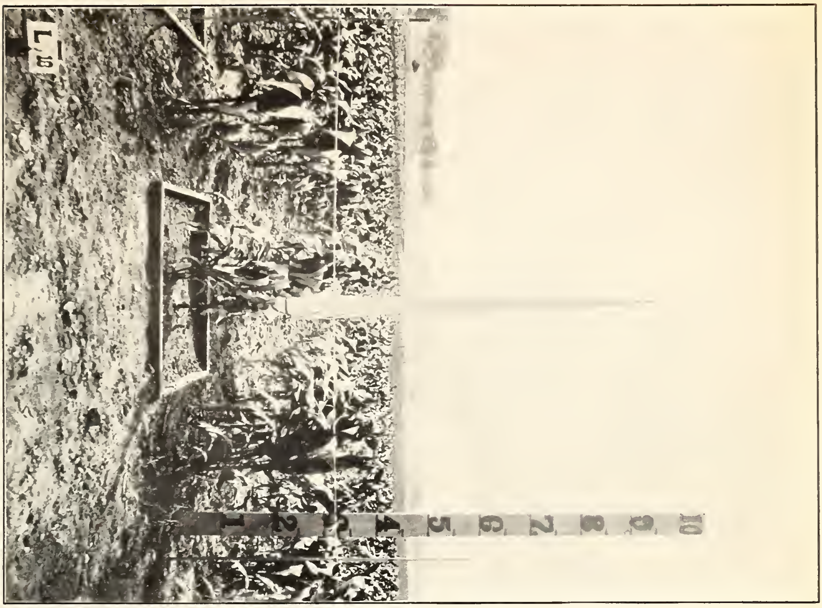
bottom cut off from the soil below by a double layer of lath. There was thus secured, on each of the two types of soil at each station, one set of cubes, 4 feet on a side, where the soil was left in its natural undisturbed condition, and which contained the natural amount of moisture of the field at the time, but from which all supplies of moisture from the sides and from the bottom were cut off, and a second set of cubes in which, while the supplies of moisture from the sides were cut off, there was free opportunity left for a capillary rise of moisture from below.

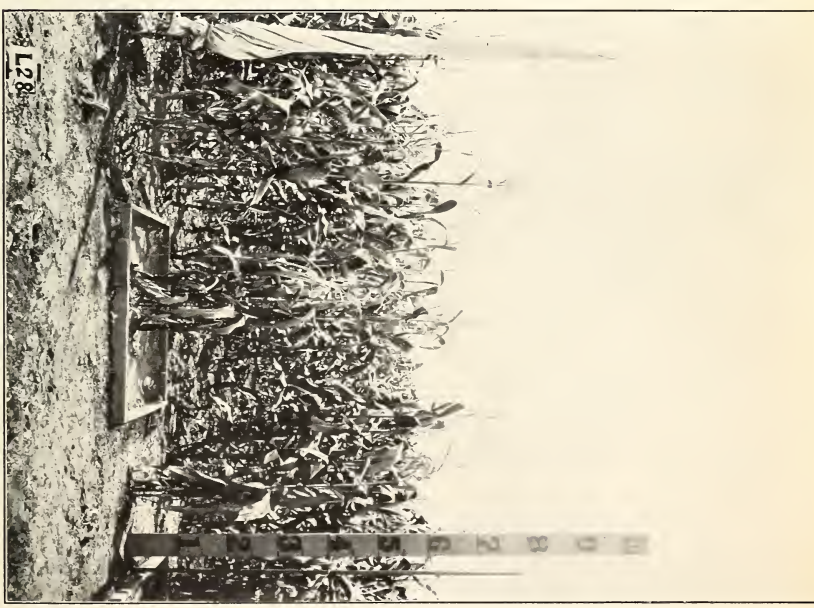
Amounts of Moisture in the Soil.

At the time the cubes of soil were isolated samples of soil were taken on the 4 sides of each cube, just outside, in 1-foot sections, to a depth of 4 feet, and the water content was determined to indicate the amount of moisture present in the soil at the time the corn was planted. Samples of soil were also taken on July 25, both within the cubes and on the 4 sides without. The samples from the cubes consisted of composites of 3 cores, while the samples from without were composites of 4 cores, all samples being taken so as to represent the first 6 inches, the second 6 inches, the second foot, the third foot, and the fourth foot. Again, at the time the corn was harvested, a similar set of samples of soil was taken and moisture determinations were made.

It transpired that on the 2 types of soil at Goldsboro, with the comparatively heavy rainfall of the season, the water table became so high that it was several times carried above the bottoms of the cubes, and water was introduced into the cubes from below through the rise of the ground water. The results, therefore, at Goldsboro are modified through this cause. At Marlboro it transpired that before the guards had been thrown about the cubes of soil a heavy rain occurred, which resulted in carrying considerable water upon the blocks, saturating the surface, and even perhaps producing percolation. At this station, therefore, the character of the results was more or less influenced by this occurrence. At Lancaster and Janesville there were no serious accidents to prevent the experiments being carried through the season essentially as they were planned, with the exception that on one of the blocks of soil at Janesville—the Miami loam—a heavy windstorm tore loose the tent pegs and the whipping of the tent so injured one of the hills that it was practically destroyed.

In the next table are given the moisture contents of the soils at the beginning of the season when the corn was planted:





BLOCKS OF SOIL CUT OFF IN FIELD WITH ONE HILL OF CORN IN CENTER; TENT TO KEEP OFF RAIN FURLED ABOUT POLE.

Moisture in the 8 soils at the time of planting—1903.

Block and depth.	Goldsboro, N. C.		Marlboro, Md.		Lancaster, Pa.		Janesville, Wis.	
	Norfolk sandy soil.	Selma silt loam.	Norfolk sand.	Sassafras sandy loam.	Hagerstown clay loam.	Hagerstown loam.	Janesville loam.	Miami loam.
Blocks cut off at bottom:	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
First foot	1.419	3.229	1.96	2.53	2.56	2.45	3.40	2.81
Second foot	1.972	5.172	2.65	3.22	3.30	4.37	3.17	2.37
Third foot	3.196	5.314	3.22	4.26	4.09	4.82	3.05	2.31
Fourth foot	3.496	....	2.76	4.60	5.08	5.61	3.79	2.68
Blocks with bottom intact:								
First foot	1.632	2.138	1.61	2.42	2.09	3.29	4.37	2.39
Second foot	3.024	4.659	2.76	2.99	3.65	4.24	2.82	3.41
Third foot	3.176	5.349	3.91	3.34	4.55	5.15	3.17	2.31
Fourth foot	3.454	....	2.65	3.34	5.31	5.35	3.68	3.04

When the samples of soil were taken the second time the moisture contents were found to be as given in the next table.

Amounts of moisture in the 8 soils on July 25—1903.

Source and depth.	Goldsboro, N. C.		Marlboro, Md.		Lancaster, Pa.		Janesville, Wis.	
	Norfolk sandy soil.	Selma silt loam.	Norfolk sand.	Sassafras sandy loam.	Hagerstown clay loam.	Hagerstown loam.	Janesville loam.	Miami loam.
Blocks with bottom cut off:	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
First 6 inches	.196	.23	.46	.61	.92	.97	1.01	1.05
Second 6 inches	.61	.84	.771	1.53	1.35	1.62	1.44	1.55
Second foot	2.365	4.22	1.53	2.45	3.23	4.06	3.26	2.58
Third foot	3.49	5.67	2.30	3.07	4.20	4.87	3.46	3.07
Fourth foot	1.23	....	1.98	3.45	4.18	4.18	4.28	2.54
Soil outside these blocks:								
First 6 inches	.725	.61	.806	1.04	1.36	1.40	1.62	1.20
Second 6 inches	.92	1.67	.92	1.50	1.84	1.78	1.86	1.68
Second foot	2.42	4.60	2.99	2.76	4.06	4.70	3.35	2.44
Third foot	3.28	4.89	3.34	2.68	4.91	4.72	3.95	2.94
Fourth foot	1.84	....	2.30	4.37	5.01	4.98	4.65	3.08
Blocks with bottom intact:								
First 6 inches	.276	.345	.46	.771	1.05	.886	1.14	1.10
Second 6 inches	.610	1.02	.771	1.07	1.35	1.69	1.57	1.35
Second foot	2.53	3.04	1.84	2.76	3.36	3.56	3.28	2.50
Third foot	2.76	4.65	3.22	2.61	4.64	4.29	3.51	2.30
Fourth foot	3.68	4.62	3.30	2.76	4.78	4.25	4.70	2.30
Soil outside these blocks:								
First 6 inches	.691	.541	.92	1.04	1.58	1.44	1.61	1.13
Second 6 inches	1.07	.599	.92	1.15	1.91	2.07	1.66	1.44
Second foot	2.76	4.43	2.88	2.76	3.81	4.49	3.41	2.44
Third foot	3.11	4.55	3.68	3.45	4.85	5.18	3.66	2.37
Fourth foot	3.48	4.03	3.11	3.57	5.69	5.66	4.40	4.05

Again, at the close of the season, when the corn was mature, the moisture was determined for a third time, and the results are given in the next table.

Inches of moisture in the 8 soils at the close of the season—1903.

Source and depth.	Goldsboro, N. C.		Marlboro, Md.		Lancaster, Pa.		Janesville, Wis.	
	Norfolk sandy soil.	Selma silt loam.	Norfolk sand.	Sassafras sandy loam.	Hagerstown clay loam.	Hagerstown loam.	Janesville loam.	Miami loam.
Blocks with bottom cut off:	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
First 6 inches	0.886	1.97	0.46	0.806	0.791	0.552	0.691	0.702
Second 6 inches			.311	.460	.96	.97	.794	1.25
Second foot	2.42	4.41	1.61	2.30	2.91	2.54	2.09	2.38
Third foot	2.91	5.26	1.96	2.99	3.48	4.48	2.82	2.89
Fourth foot	1.89	....	1.50	4.14	3.72	3.51	3.41	2.60
Soil outside these blocks:								
First 6 inches	1.61	2.42	.92	1.15	1.63	2.12	1.99	1.71
Second 6 inches			.92	1.04	1.42	1.61	2.21	1.96
Second foot	2.99	4.83	2.88	2.96	3.87	3.57	3.30	2.82
Third foot	3.29	5.26	2.53	4.60	5.00	4.35	3.68	2.86
Fourth foot	2.08	....	2.42	4.49	5.39	4.20	4.30	3.46
Blocks with bottom intact:								
First 6 inches	.84	1.39	.46	.61	.98	1.07	.725	.76
Second 6 inches			.311	.771	1.32	1.01	1.38	.97
Second foot	2.61	3.99	1.84	1.99	3.49	3.88	2.54	2.34
Third foot	2.94	5.52	3.22	2.30	4.93	4.48	3.45	1.43
Fourth foot	3.73	2.94	2.30	2.61	5.39	5.43	3.87	1.39
Soil outside these blocks:								
First 6 inches	1.57	2.21	1.38	1.38	1.27	1.57	1.93	....
Second 6 inches			.92	1.04	1.71	1.27	2.12	....
Second foot	2.65	4.35	3.22	2.30	3.76	2.88	3.10	....
Third foot	3.11	5.51	3.45	2.99	4.56	4.88	3.41	....
Fourth foot	3.34	2.62	3.22	2.76	5.41	4.21	4.49	....

Comparison of Results for Two Soils Types.

When the data of the preceding tables, relating to the Lancaster and Janesville soils, are tabulated on the basis of the depth and subdivided on the basis of moisture inside and outside of the cubes, the results appear as given in the next table, where the average amounts of water under the two conditions and for the respective depths appear in the third line from the last in each section of the table; in the next to the last line are given, in inches, the differences between the absolute amounts of moisture in the outside soil and the soil within the cubes; while the last line expresses the difference per 6 inches of depth, these values being obtained by dividing the data for the full foot sections by two.

Amounts of water expressed in inches in soils within and adjacent to cubes of soil cut off by lath and sheltered from rain by tents—1903.

INCHES OF WATER AT THE CLOSE OF THE SEASON.

Soil.	0–6 inches.		6–12 inches.		12–24 inches.		24–36 inches.		36–48 inches.	
	In cube.	Outside.	In cube.	Outside.	In cube.	Outside.	In cube.	Outside.	In cube.	Outside.
Hagerstown clay loam:										
With bottom cut off	0.791	1.63	0.96	1.42	2.91	3.87	3.48	5.00	3.72	5.39
With bottom intact	.980	1.27	1.32	1.71	3.49	3.76	4.93	4.56	5.39	5.41
Hagerstown loam:										
With bottom cut off	.552	2.12	.97	1.61	2.54	3.57	4.48	4.35	3.51	4.20
With bottom intact	1.070	1.57	1.01	1.27	3.88	2.88	4.48	4.88	5.43	4.21
Janesville loam:										
With bottom cut off	.691	1.99	.794	2.21	2.09	3.30	2.82	3.68	3.41	4.30
With bottom intact	.725	1.93	1.38	2.12	2.54	3.10	3.45	3.41	3.87	4.49
Miami loam:										
With bottom cut off [a]	.702	1.71	1.25	1.96	2.38	2.82	2.99	2.86	2.60	3.46
With bottom intact [a]	.760	....	.97	....	2.34	....	1.43	....	1.39	....
Average	.784	1.746	1.082	1.757	2.771	3.329	3.508	4.106	3.665	4.494
Excess	....	.962	....	.675	....	.558	....	.598	....	.829
Excess per 6 inches	....	.962	....	.675	....	.279	....	.299	....	.415

INCHES OF WATER PRESENT JULY 25.

Soil.	0–6 in cube.	0–6 outside.	6–12 in cube.	6–12 outside.	12–24 in cube.	12–24 outside.	24–36 in cube.	24–36 outside.	36–48 in cube.	36–48 outside.
Hagerstown clay loam:										
With bottom cut off	0.920	1.36	1.35	1.84	3.23	4.06	4.20	4.91	4.18	5.01
With bottom intact	.050	1.58	1.35	1.91	3.36	3.81	4.64	4.85	4.78	5.69
Hagerstown loam:										
With bottom cut off	.970	1.40	1.62	1.78	4.06	4.70	4.87	4.72	4.18	4.98
With bottom intact	.886	1.44	1.69	2.07	3.56	4.49	4.29	5.18	4.25	5.66
Janesville loam:										
With bottom cut off	1.010	1.62	1.44	1.86	3.26	3.35	3.46	3.95	4.28	4.65
With bottom intact	1.140	1.61	1.57	1.66	3.28	3.41	3.51	3.66	4.70	4.40
Miami loam:										
With bottom cut off [a]	1.050	1.20	1.55	1.68	2.58	2.44	3.07	2.94	2.54	3.08
With bottom intact [a]	1.100	1.13	1.35	1.44	2.50	2.44	2.30	2.37	2.30	4.05
Average	1.016	1.418	1.490	1.780	3.230	3.588	3.793	4.073	3.901	4.690
Excess	....	.402	....	.290	....	.358	....	.280	....	.789
Excess per 6 inches	....	.402	....	.290	....	.179	....	.140	....	.395

INCHES OF WATER IN THE SOIL AT START. [b]

Soil.	0–6 in cube.	0–6 outside.	6–12 in cube.	6–12 outside.	12–24 in cube.	12–24 outside.	24–36 in cube.	24–36 outside.	36–48 in cube.	36–48 outside.
Hagerstown clay loam:										
With bottom cut off	2.56	....	....	....	3.30	....	4.09	....	5.08	....
With bottom intact	2.09	....	....	....	3.65	....	4.55	....	5.31	....
Hagerstown loam:										
With bottom cut off	2.45	....	....	....	4.37	....	4.82	....	5.61	....
With bottom intact	3.29	....	....	....	4.24	....	5.15	....	5.35	....
Janesville loam:										
With bottom cut off	3.40	....	....	....	3.17	....	3.05	....	3.79	....
With bottom intact	4.37	....	....	....	2.82	....	3.17	....	3.68	....
Miami loam:										
With bottom cut off	2.81	....	....	....	2.37	....	2.31	....	2.68	....
With bottom intact	2.39	....	....	....	3.44	....	2.31	....	3.04	....
Average	2.92	....	....	....	3.42	....	3.681	....	4.318	....
Average for 6 inches	1.46	....	....	....	1.71	....	1.841	....	2.159	....

[a] See footnote on page 204.

[b] In the last section of this table the figures in the first column show the moisture in the first foot instead of the first 6 inches.

When the absolute amounts of moisture expressed in inches found in the Lancaster and Janesville soils in the two sets of cubes are classified, so as to group those obtained from the soil from which the moisture from below was cut off in one group, and those from the groups which could acquire water from below in a second group, the results appear in the following table:

Comparison between the water content of blocks of soil where capillary rise was cut off from below and where it was not cut off—1903.

DEPTH OF WATER IN INCHES AT THE CLOSE OF SEASON.

Soil.	0–6 inches.		6–12 inches.		12–24 inches.		24–36 inches.		36–48 inches.	
	With bottom cut off.	With bottom intact.	With bottom cut off.	With bottom intact.	With bottom cut off.	With bottom intact.	With bottom cut off.	With bottom intact.	With bottom cut off.	With bottom intact.
Hagerstown clay loam	0.791	0.980	0.960	1.32	2.91	3.49	3.48	4.93	3.72	5.39
Hagerstown loam	.552	1.070	.970	1.01	2.54	3.88	4.48	4.48	3.51	5.43
Janesville loam	.691	.725	.794	1.38	2.09	2.54	2.82	3.45	3.41	3.87
Miami loam	.702	.760	1.250	.97	2.38	2.34	2.89	1.43	2.60	1.39
Average	.684	.884	.994	1.17	2.48	3.063	3.418	3.573	3.31	4.02

DEPTH OF WATER IN INCHES ON JULY 25.

Soil.	0–6 inches.		6–12 inches.		12–24 inches.		24–36 inches.		36–48 inches.	
	With bottom cut off.	With bottom intact.	With bottom cut off.	With bottom intact.	With bottom cut off.	With bottom intact.	With bottom cut off.	With bottom intact.	With bottom cut off.	With bottom intact.
Hagerstown clay loam	0.920	1.05	1.35	1.35	3.23	3.36	4.20	4.64	4.18	4.78
Hagerstown loam	.97	.886	1.62	1.69	4.06	3.56	4.87	4.29	4.18	4.25
Janesville loam	1.01	1.14	1.44	1.57	3.26	3.28	3.46	3.51	4.28	4.70
Miami loam	1.05	1.10	1.55	1.35	2.58	2.50	3.07	2.30	2.54	2.30
Average	.9875	1.044	1.49	1.49	3.28	3.18	3.90	3.685	3.795	4.008

From this table it will appear that the water content at the close of the season for each of the depths, excepting the last three in the Miami loam, was notably less in the soil of the cubes from which the possibility of supply from below was cut off; but in the case of the water content on July 25 the differences are less marked, and, although showing the same general tendency, there are exceptions to the statement just made.[a]

In the next table the data of the preceding table are combined, so as to show the total water content in inches for the 4 feet in each of the 4 pairs of blocks. In the first section of the table there is shown the amounts and differences of the water content in the blocks at the close of the season, and in the second section of the table the same facts are shown for July 25. From this grouping it appears that the cutting off of the capillary supply from below 4 feet has resulted in a deficiency of 1.824 inches at the close of the growing season, while no appreciable difference had yet appeared at the end of July. The case, therefore, appears fairly conclusive that appreciable amounts of moisture from depths below 4 feet are supplied during the growing season to the

[a] The exceptions in case of the Miami loam are so remarkable and so difficult to explain as matters of fact that the accuracy of the records may be doubted. The only reasonable explanation on the basis of error in record is that in some manner the field records both for July and September might have been transposed.—F. H. K.

superficial 4 feet, so that moisture and whatever of salt content is carried by it exert an influence on the yield of the crop. If the differences in the water content shown by the observations are really due to the effect of cutting off capillary supply from below, it does not at all follow that the 1.824 inches is a measure of the magnitude of the supply from below. All that can be said in regard to it is that, while it expresses the difference which had accumulated at the close of the season, the actual amount of moisture which passed from below 4 feet into the zone of soil above may have been two, three, or more times the difference which is shown.

Aggregate water content of the 4 soils where the blocks were cut off at bottom and where not cut off—1903.

Depth.	At close of season.		On July 25.	
	Upward capillarity cut off.	Upward capillarity not cut off.	Upward capillarity cut off.	Upward capillarity not cut off.
Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*
0–6	0.684	0.884	0.9875	1.044
6–12	0.994	1.170	1.4900	1.490
12–24	2.480	3.063	3.2800	3.180
24–36	3.418	3.573	3.9000	3.685
36–48	3.310	4.020	3.7950	4.008
Total	10.886	12.710	13.4525	13.407
Excess	....	1.824	.0455	....

COMPARATIVE YIELDS UNDER THE DIFFERENT CONDITIONS.

The comparative yields of dry matter from the different blocks of soil are given in the table next following:

Total weight (air dry) per acre of entire corn plants and of ears grown on 8 soils in block cut off from surrounding soil and protected from rain—1903.

Product and soil cube.	Goldsboro, N. C.		Marlboro, Md.		Lancaster, Pa.		Janesville, Wis.	
	Norfolk sandy soil.	Selma silt loam.	Norfolk sand.	Sassafras sandy loam.	Hagerstown clay loam.	Hagerstown loam.	Janesville loam.	Miami loam.
Total weight of entire plants on soil cube:	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
With bottom cut off	684	753	1,524	953	1,134	578	1,462	1,457
With bottom intact	1,230	513	2,232	599	672	592	1,798	....
Total weight of ears on soil cube:								
With bottom cut off	336	716	000	000	102	114	249	294
With bottom intact	830	459	272	000	48	42	294	....

From the results regarding yields, the only conclusion which it appears legitimate to draw is that the moisture relations came to be so prejudicial to growth that in no case could the development be even approximately normal. The plants, it is true, lived on and came to maturity, but they were small and most of them did not produce any ears at all.

O